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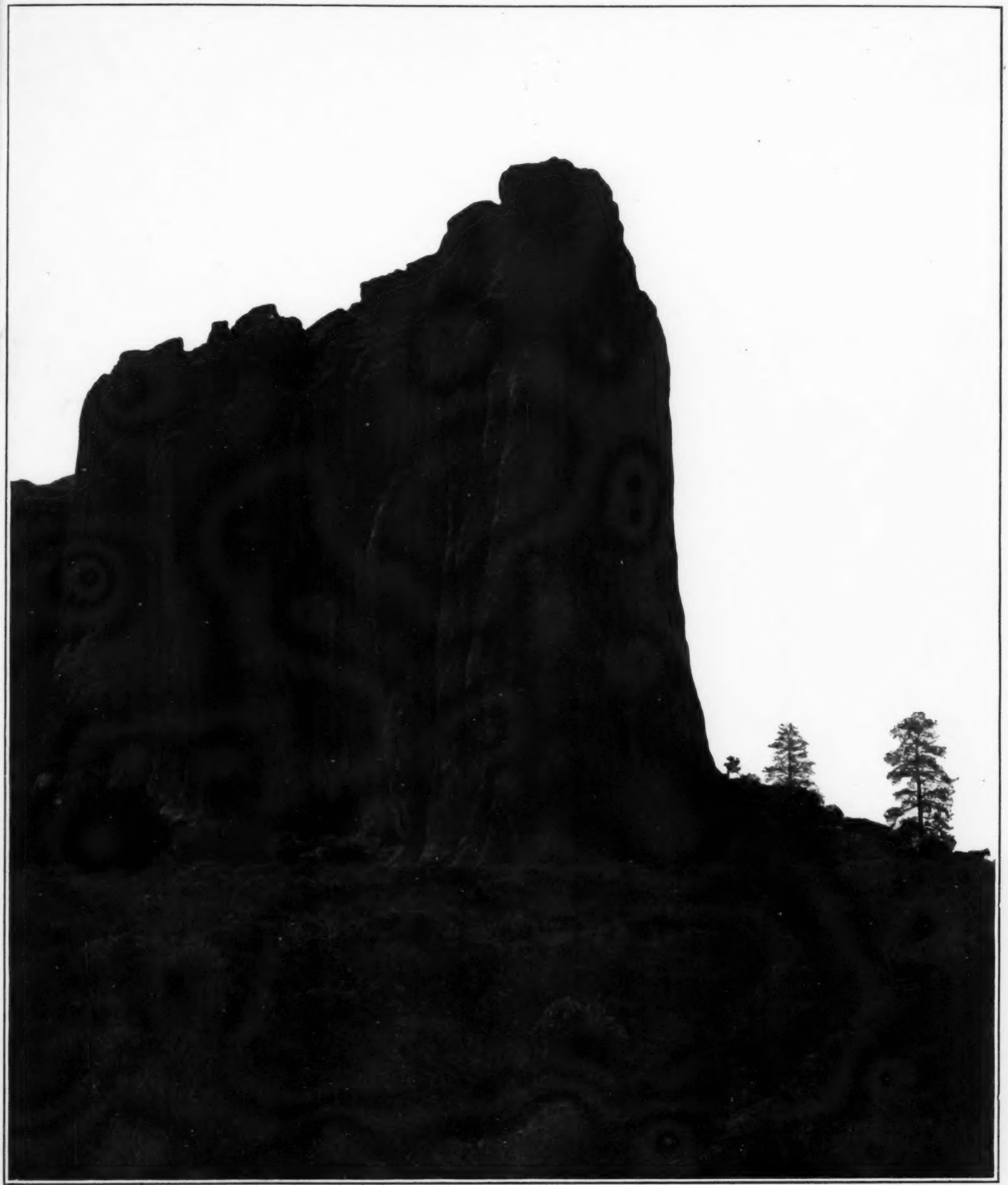


Photograph by the Bureau of American Ethnology of the Smithsonian Institution.

El Moro, the castle, viewed from the trail to the East, a great natural fortress-like rock which stands a time-defying monument.

STONE RECORDS OF THE HISTORY OF NEW MEXICO.—**[See page 388.]**

The Healing Virtue of Light

The Medical Art of Chromotherapy

The art of healing by colored light, to which the name chromotherapy was applied hardly more than twenty years ago, is discussed in *La Revue* by Dr. Laumonier. After a brief introduction of historical examples of such treatment empirically, especially in cases of measles, scarlet fever, and small-pox, he continues:

"The modern method of treatment by colored light is principally based on the studies of Engelmann and Winogradski. These authors, experimenting on unicellular organisms, vegetable and animal, such as algae, bacteria, antheroizoids, protozoa, etc., have established that the manifestations of elementary life present their optimum normal activity between the orange and the green of the solar spectrum. If we project a small spectrum on a drop of water containing different microbes, we perceive, after a time, that the microbes have become assembled in the region of the orange-yellow, yellow, and yellowish-green rays. This is not merely the result of a mechanical attractive influence; vital reactions have been effectually increased, as shown by the abundance of gaseous disengagement and the greater rapidity of cellular bipartition.

"Two other phenomena are equally notable. On the one hand, in the red and infra-red, which represent the hottest and most penetrating part of the spectrum, the vital activity of the microbes is exaggerated, but soon ceases, as if exhausted by their very excess.

"On the other hand, in the blue-indigo, the violet and the ultra-violet, the part of the spectrum richest in chemical radiations, the vital activity progressively slackens and disappears, by the gradual destruction of the living matter, which degenerates.

"From the biologic point of view, therefore, there are three fundamental regions in the spectrum: the red, temporarily superexcitant, but finally exhausting; the yellow, and above all, the green, endowed with a lasting power of maintaining equilibrium; and, finally, the blue and the violet, sedatives at first, but subsequently inhibitors and destructive irritants.

"But if colored light produces such effects on isolated living cells, how does it act on the tissues of complex organisms, and, especially, on the nervous elements, the most sensitive of all?

"This question is answered by the numerous researches made by Young, Semper, Forel, and others on the larvæ of insects, tadpoles, etc., which all attest the influence exerted on nutrition and development by the different regions of the solar spectrum.

"Apart from phototherapy and heliotherapy, which utilize the total white light, solar or other, we find in the memoir of Dr. Bie, presented to the Congress of Wiesbaden in 1902, the first systematic essay on chromotherapy. Bie also found the red exciting, green stabilizing, and violet sedative. He proved, moreover, as indicated by Prof. Charles Bouchard, that red light does not irritate the skin, but has a power of penetration much greater than the blue, which on the contrary, though highly irritated, is superficial in action. Shortly afterward, Dreyer, of Copenhagen, sought to make use of these discoveries by injecting or painting the integuments with histochemical red solutions (trypan red, for example), to render them more permeable to the bactericidal action of blue or violet rays. We know, too, that many other colors, the methylene blue, methyl violet, eosin, etc., have been used against certain injections—ocular, gynecologic, cancerous, etc., but it is believed at present that the colloidal state of these colored substances has more influence than their coloration.

. . . "Finsen, the great protagonist of phototherapy, utilized red light—like the Chinese—against small-pox, and blue light against eczema, lupus and certain malignant tumors of the skin. His success encouraged others to try his method, and thus Thymann, Bickerod, and Schoull used it against scarlet fever. Chopf, of the Nuremberg Children's Hospital, reported that under the influence of a sojourn in the 'red room,' the exanthema of the little invalids paled and disappeared, fever lessened and complications lost their gravity. But when the stay was not sufficiently prolonged the eruption and fever reappeared after the emergence from the room.

"Equally satisfying results were obtained by Bie in small-pox; by Krukenberg in erysipelas, it being sometimes sufficient merely to paint the pimples or blotches with red. But it is especially against measles that the treatment with red light (erythrotherapy) is recommended."

The author cites many physicians who support this practice, but confesses there are others who question its efficacy. Dr. Gougert made some interesting tests, whose results he reported in the Prese Medicale in 1909.

He installed a red room in the measles ward of the Claude-Bernard Hospital by pasting red paper on the window panes and putting red shades on the electric lights. Likewise the patients were clad in red garments. Of the 24 patients all over 15 years, there were none who died and only two whose cases were complicated by laryngitis. The initial conjunctivitis and the swelling of the face were favorably affected. The eruption was perhaps somewhat lessened, but the fever was not modified. Hence he gives qualified support to the treatment. The author finds Gougert too pessimistic and thinks the test not conclusive; first, because the epidemic was of a mild type; second, because the sojourn (averaging two days) was too short; and third, because the subjects were all adults, "less exposed to the gravity of the infection than children, and with integuments more resistant to the penetration of the red rays." He continues: . . . "The red rays are not bactericidal; they act through the nervous system on which they exert a dynamogenic action so strong that it may result in a veritable state of excitation. . . . But this action and the reinforcement of the vital resistance consequent upon it are dependent on the penetration of the red rays. But this penetrability, itself conditioned by the structure of the integuments, . . . is considerably weakened in the adult, whose skin is thicker and harder. . . .

"The blue and violet light operate differently. With less penetrating power it is . . . energetically bactericidal and irritating to the skin. The violet and ultra-violet rays, especially from the mercury-vapor lamp, are used with success for the sterilization of water and even of milk. Their use in medicine (cyanotherapy) has not always been well interpreted, and this is why we are astonished to find that in lupus, eczema and erysipelas, Finsen and Rumpf prescribe the blue light, while Winternitz, Unna and Krukenberg prefer red light in the same cases. But the red and blue lights, despite their diverse properties, may readily produce similar therapeutic results. Here are two facts which prove this. A young girl, attacked by a purely tropo-neurotic eczema, found her affection slightly aggravated by the blue light, while she was rapidly cured by the red rays. On the contrary, a man of 55, suffering from chronic suppurating eczema, derived no benefit from the red rays, but later found his lesions rapidly ameliorated by the methodic application of blue light. The interpretation of these apparent contradictions is simple. In the first case the red light alone could be useful because penetrating and dynamogenic. In the second case only the blue light could give satisfactory results, since the state of the skin and the nervous system rendered the first less penetrable to the red rays and the second less sensitive to their action, . . . and moreover the blue rays are especially active against that particular affection of the skin.

"Consequently, erythrotherapy and cyanotherapy are equally apt in certain cases to produce the amelioration of the same morbid condition, but the first maintains or augments the vital resistance and the natural defenses of the organism, while the second limits its action to the reduction of the activity and of the virulence of microbes.

"Both are equally used in psychotherapy. As far back as 1890 de Courmelles prescribed blue or violet light for certain dental troubles. I have also noted that the same color was soothing in intercostal neuralgia. Finally Finsen observed that the violet and ultra-violet rays relieved in some degree the pain of superficial cancers and cancers of the breast.

"From a purely psychotherapeutic point of view results seem still more valuable. In a red atmosphere depressed neurasthenics, and victims of alcohol, hypochondria, or melancholia, nearly always improve and recover the desire of activity and the need of movement.

Inversely, in a blue or violet atmosphere excited, delirious, or maniacal patients little by little regain tranquility. Dr. Farez utilized these properties to obtain with more facility hypnosis and therapeutic suggestion. Placed in a red chamber if they had need of stimulation, in a blue or violet if they needed calming, the patients responded better to the questions of the doctor, explained their condition more fully and thus profited the better by his advice."

The Synthesis of Ammonia from Its Elements—I*

The Commercial Exploitation of the Earth's Atmosphere

By H. A. Bernthsen

You all know that of the chemical elements that occur in large quantity on our planet, nitrogen is one which is characterized by its complete indifference to chemical attack. Berzelius already says of it: "It is difficult to recognize because it does not differ from other gases by any conspicuous property, but can only be recognized by means of properties which it does not possess." We see therefore both in science and in arts that nitrogen is frequently used when it is desired to protect bodies from chemical attack by oxygen or when the commencement of an oxidation is to be prevented. The vacuum of the thermometers in instruments which are intended for high temperatures is, as you are aware, filled with nitrogen. The storage of readily combustible liquids, such as coal tar benzene and light petroleum naphtha, is effected by covering these bodies with nitrogen; their transport by applying compressed nitrogen. It is to the indifference of this element to chemical attack that the curious state of affairs must be attributed, that although we are dependent for all the conditions of life on compounds of this body and although we live in an infinite ocean of nitrogen, yet up to a short time ago we were not in a position to obtain nitrogen compounds from it. We were forced to cover our requirements of saltpeter for gunpowder, of nitric acid for gun-cotton and for nitration and many other applications, of ammonia for refrigerators, for instance, and so on, not by drawing upon the nitrogen of the air, but by utilizing ready formed nitrogen compounds, which ultimately result from the processes of plant life of earlier times. On the one hand Chili saltpeter and on the other hand the ammonia liquor obtained in small proportions as a by-product in the manufacture of gas or coke from coal served to supply the wants mentioned. We were also and in particular dependent on these two sources of nitrogen for the requirements of agriculture, which are far greater than all the other taken together.

But now, while the requirements of nitrogenous manures are constantly increasing, in order to guarantee to the inhabitants of the world sufficient harvests, we have in all probability to reckon with a comparatively rapid diminution of the supply of natural Chili saltpeter. On the other hand we cannot expect the balance to be maintained by a rapid increase in the production of ammoniums ulphate, for this is dependent on the manufacture of gas and of coke, which increases but slowly. To this, some working up of peat may be added, but a production of ammonia in this way as the main object of manufacture is impossible. The problem of the conquest of elementary nitrogen, of forcing this obstinate scamp into the service of our civilization, has consequently attained immediate importance for some time. Already three years ago at the Seventh International Congress of Applied Chemistry in London, I therefore had the honor of reporting on the utilization of atmospheric nitrogen and a new way for the production of nitrates from the air.

It might appear that the American continent, which is so richly blessed with the treasures of nature, can perhaps await with greater patience the development of events than could most European countries. For while the soil of the latter has been worked to the uttermost through centuries of agriculture, the unexampled development of this country has been caused, to a great extent by the fact that agriculture had virgin soil at its disposal wherever it developed. There may still be places, such as the English poet Browning sings of:

"Nature frames
Some happy lands, that have luxurious names,
For loose fertility; a footfall there
Suffices to upturn to the warm air
Half-germinating spices; mere decay
Produces richer life; and day by day
New pollen on the lily petal grows,
And still more labyrinthine buds the rose."

In general, however, a change is occurring. The soil

* Paper read before the Eighth International Congress of Applied Chemistry.

of the Eastern States, if it is to yield full harvests in the future, already requires the addition of manures, above all of the nitrogenous manures, for lack of the latter is most quickly noticed by the plants. A similar treatment would further be of great advantage in many parts of the Southern cotton States. Finally, in the course of years, the same requirements will be noticed in the West more and more, as the development of hitherto uncultivated land even there now hardly comes into consideration. Nature will only continue to shower her favors on man if he adapts himself with reason to her immutable laws, as expressed by the poet:

"Nur der verdient sich Freiheit wie das Leben,
Der täglich sie erobern muss."[1]

I therefore count upon your interest if I deal to-day in some detail with the nitrogen question, and announce to you some of the progress that has been made since the last Congress.

The three methods employed for the fixation of nitrogen are: First, the direct oxidation of nitrogen of the air forming nitric acid, nitrates, etc.; second, the synthesis of ammonia from nitrogen and hydrogen; and third, the fixation of nitrogen to metals or metalloids and, if desired, subsequently decomposing the resulting products, nitrids, etc., producing ammonia. Three years ago it was the first of these ways with which I dealt principally. I was in a position to announce that in the processes of Birkeland of Christiania, on the one hand, and of Schönherr and the Badische Anilin- & Soda-Fabrik, on the other hand, two important ways had been opened up for oxidizing the atmospheric nitrogen with the aid of electricity obtained from water power. Two companies had been formed by a Norwegian-French group, the Norsk Hydro Elektrisk Kvaelstofaktieselskab, and a German group, the Badische Anilin- & Soda-Fabrik together with the Farbenfabriken of Elberfeld and the Actiengesellschaft für Anilinfabrikation of Berlin. These undertakings and some other associated enterprises have in the meantime been developed with great energy and the factory at Saaheim, which converts about 120,000 horse-power of the Rjukan fall into oxids of nitrogen, is now in full swing. The management of these works has passed into the hands of the Norwegian-French group by an arrangement with the German group.

The process for the combination of nitrogen with metals, etc., producing metallic nitrids, cyanamids, and the like, and from these ammonia, have also progressed. On the one hand the nitrolime obtained for instance by the union of nitrogen with calcium carbid, which is produced in several factories, is in part utilized directly as manure; in part a beginning has been made with the manufacture of ammonia from it by treatment with steam. On the other hand the nitrids, and especially those of aluminium and silicon, have been more closely studied. The process of Serpek for the production of aluminium nitrid has been developed by the Société Générale des Nitrures on a manufacturing scale in order to obtain on the one hand, pure alumina for the production of aluminium, and on the other, ammonia. Then again the Badische Anilin- & Soda-Fabrik in following up its work on barium cyanid from nitrogen, barytes and carbon took up the study of the production of titanium-nitrogen compounds and that of silicon nitrid from silica, nitrogen and carbon, and then in connection with this the production of mixed nitrids of silicon and aluminium, and of aluminium nitrid itself. In this field of work also an arrangement has been made between the firms working it, the Badische Anilin- & Soda-Fabrik having assigned their patents to the Société Générale, retaining for themselves certain rights of preparing the nitrids in question according to the patents of both companies. It is to be expected that this branch of industry will also develop satisfactorily.

I refrain from discussing any of these methods of fixing nitrogen and refer to the communications made by the inventors themselves and in particular to the lecture delivered a few days ago at this Congress, by Dr. Eyde,[2] the general director of the Norwegian companies referred to.

I propose to deal to-day however, from my own direct experience, with the development of the problem for the synthetical manufacture of ammonia from its elements. A few years ago the solution of this problem appeared to be absolutely impossible. It has recently been the object of very painstaking investigations by Prof. Haber and the chemists of the Badische Anilin- & Soda-Fabrik, and numerous patents have been taken out with reference to the manufacture. Apart from what is already published in this way, however, we have refrained from any other announcements until we were in a position to report something final with reference to the solution of the technical question.

This moment has now arrived and I am in the agreeable position of being able to inform you that the said problem has now been solved fully on a manufacturing scale, and that the walls of our first factory for synthetic ammonia are already rising above the ground at Oppau, near Ludwigshafen-on-Rhine; this factory will be opened by the middle of next year.

Permit me therefore to explain to you the fundamental points upon which this latest achievement of chemical industry is based.

The affinity of nitrogen for hydrogen, as is well known, is so small that the two do not appreciably unite with one another either at ordinary or at a raised temperature. It has long been known that by electric sparks or by a silent discharge very minute quantities of ammonia can be formed from nitrogen and hydrogen. Also by conducting a mixture of hydrogen with nitrogen prepared in a particular way over spongy platinum, Johnson (1881) thought that he had obtained ammonia, in a quantity amounting to 0.0059 gramme of NH_3 per hour. The nitrogen had been obtained from ammonium nitrite and passed through ferrous sulphate solution in order to remove nitric oxids. But nitrogen prepared in other ways did not yield the ammonia, so that Johnson assumed that there were two modifications of nitrogen. Wright (1881) proved that ferrous sulphate did not absorb all the nitrogen oxids and that the ammonia was produced by the action of hydrogen on nitrogen oxid in the presence of platinum. When using pure nitrogen he also obtained no ammonia. Baker (1883) also came to the conclusion that Johnson's statements as to the production of ammonia from its elements were mistaken. In no case could Baker notice any signs of the formation of ammonia, and he decided that hydrogen does not combine with nitrogen under the influence of heated platinum sponge.

Ramsay and Young on the other hand (1884) determined the decomposition of ammonia by heat at various temperatures. In this research, among other experiments, a mixture of dry nitrogen and hydrogen was passed through a red-hot glass tube filled with iron filings, or through an iron tube. The presence of ammonia could again not be proved. When using moist gases they noticed the presence of traces of ammonia, the formation of which they explained by the decomposition of water and the production of nascent hydrogen.

Again, Perman, twenty years later, occupied himself with the question of the formation of ammonia from its elements. Upon slowly passing a mixture of nitrogen and hydrogen (1 vol.: 3 vol.) through a glass tube heated to red heat, he obtained no ammonia, and the same result was attained when the tube was filled with porcelain. But when the mixture, in a moist condition, was passed over red-hot iron or several other metals, or over asbestos, pumice, pipe-clay, etc.,[3] traces of ammonia were formed, according to Perman's statement.

The investigations entered upon a new phase when Haber, armed with the weapons of modern physical-chemical methods, attacked the problem of the estimation of the ammonia equilibrium in 1904 in conjunction with van Oordt.[4] These investigators showed that at a temperature of about 1,000 deg. Cent. decomposition of ammonia into its elements was almost, but not quite, quantitative (of 1,000 molecules of ammonia 999.76 were decomposed at a temperature of 1,020 deg. Cent.), and that consequently from these elements and under the same conditions very small quantities of ammonia were formed. The authors used as contact material, iron prepared from iron oxalate by heating to red heat in a current of hydrogen, and the iron was spread out upon purified asbestos. Further, for some experiments nickel was precipitated from nickel nitrate upon pure silica. From a mixture of nitrogen and hydrogen corresponding to 100 parts of ammonia they obtained at the temperature mentioned about 0.02 parts of ammonia, and even this figure was subsequently, by more accurate examination (see below), shown to be still too high. In a further publication in 1905,[5] these results were confirmed and summarized in the following statement: at the temperature of commencing red heat and upward, no catalyzer is capable of producing more than traces of ammonia. The work was carried out at ordinary atmospheric pressure "for practical reasons," and it was pointed out that even under considerable increased pressure the position of the equilibrium would remain very unfavorable. Manganese was also taken into consideration as a catalyzer, but its effect, as also that of nickel, was less satisfactory than that of iron.

While Haber in company with Le Rossignol[6] pursued this line of research, Nernst communicated the results of similar investigations to the general meeting of the German Bunsen Gesellschaft at Hamburg in 1907.[7] He was induced to take the matter up by the fact that Haber's figures showed a remarkable discrepancy from the equilibrium figures calculated according to the famous "heat theorem" of Nernst himself. In order to determine the otherwise so minute quantities of ammonia, Nernst worked under pressure, using as a rule about 50 and up to 75 atmospheres, for according to the well-known laws the concentration of the ammonia increases with the pressure. These results were published more in detail a year later by his co-worker, Jost.[8] The latter used as catalysts besides platinum foil or iron (prepared from iron oxid in a current of hydrogen) also manganese (obtained from an electrically prepared amalgam by driving off the mercury in a current of ammonia). The figures here obtained for the equilibrium were still lower than Haber's, a fact which Nernst said was very regrettable, for otherwise one might really have thought of preparing ammonia synthetically from hydrogen and nitrogen, Haber and Le Rossignol made a further publication in 1908,[9] having now made their measurements also at a pressure of 30 atmospheres. By this means, it is true, the differences as against Nernst's experiments on account of the position of equilibrium, as also the maximum percentage of ammonia obtainable at a given temperature, were not quite got over, but at all events the figures of both scientists agreed in showing that this maximum is extremely low. At a temperature of 1,000 deg. Cent. the volume percentage of ammonia calculated for atmospheric pressure is 0.0048 per cent according to Haber and 0.0032 per cent according to Jost, the corresponding figures at 700 deg. Cent. being 0.0221 per cent and 0.0174 per cent.[10] That is, at these temperatures the ammonia equilibrium is extremely unfavorable, while at lower temperatures the catalytic action of the metals in question was too low to be able to work with them.

To be continued.

[1] "He only earns his liberty, as his living, who day by day must win it by the dint of battle."

[2] See SCIENTIFIC AMERICAN SUPPLEMENT, No. 1925.

[3] The action of these latter bodies was explained by the presence of iron in them, but it may be stated that the alleged action of asbestos, pipe-clay and pumice is due to a mistake.

[4] *Z. anorg. Chem.*, 43, 111.

[5] *Ibid.*, 44, 341.

[6] *Ber.*, 40, II, 2,144 (1907).

[7] *Zeit. für Elektrochemie*, 13, 521 (1907).

[8] *Z. anorg. Chem.*, 57, 414.

[9] *Zeit. für Elektrochemie*, 14, 181 (1908).

[10] *Z. anorg. Chem.*, 57, 193; *Zeit. für Elektrochemie*, 14, 193.

Artificial Silks

ARTIFICIAL silk is fast coming to be a very important textile material and is being used in ever-increasing quantities by the trade. It is employed as an adjunct not only to the silk industry itself, but is also being used in connection with wool and cotton in the preparation of a great variety of fabrics. It is even being used largely in knit goods and hosiery in combination with cotton and mercerized cotton.

The dyer, therefore, is meeting more and more with this product, and as there are three different kinds of artificial silks in general use, and as these different varieties possess certain differences in structure and quality, it really becomes a question of considerable importance to the dyer to know one variety from another. This is more especially important because one silk may stand a treatment which would be fatal to another.

The three artificial silks now to be met with on the market are described in a recent issue of the *Wool and Cotton Reporter* as follows:

1. Collodion silk, known also as Chardonnet, or nitrosilk. It is prepared from nitrated cotton.

2. Cuprate silk, known also as Glanzstoff, Pauly, Elberfeld silk. It is prepared from a solution of cellulose in cuprammonium solution.

3. Viscose silk. This is prepared from a solution of cellulose in a mixture of caustic soda and carbon disulphide.

In their outward appearance the three forms of artificial silk are so nearly alike that it would not be possible to distinguish between them. Even a microscopic examination by an experienced observer does not lead to any positive conclusion as to kind of silk.

A fairly simple test, however, and one which may be easily carried out by the average dyer, is the following: A sample of the silk to be tested is placed in a small porcelain dish, and concentrated sulphuric acid is poured over the fibers. If the sample consists of collodion silk no coloration appears until about an hour has elapsed, when the acid solution will acquire a pale yellow color.

In the case of cuprate silk the acid becomes yellow immediately and the color becomes deeper on standing. In the case of viscose silk the acid immediately develops a reddish brown color, deepening to a rusty brown after standing for an hour.

Photograph by the Bureau of American Ethnology of the Smithsonian Institution.

A Near View of the Northeast Pinnacle of El Morro, Which Raises its Titanic and Rugged Mass from the Broken Plane Below.

Photograph by the Bureau of American Ethnology of the Smithsonian Institution.

The Writings by Lieut. Barba, Naming His Compatriots, Arechuleta and Ynojos, in the Campaign of 1636.

Stone Records of the History of New Mexico

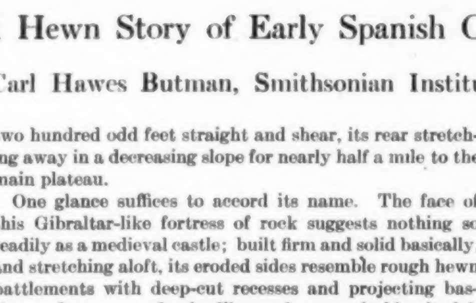
The Rock Hewn Story of Early Spanish Occupation

By Carl Hawes Butman, Smithsonian Institution

Without keeping in touch even with all the details of the many exploration parties which are continually excavating and searching among the ruins of the Old World, its ancient temples, tombs, and dwellings, for inscription-tablets, specimens of art, and other archæological and ethnological treasures, we are so busy as to overlook the fact that in the New World there is also a field for such investigation and for the preservation of much valuable material. Most of us are undoubtedly aware, in an inexact sort of way, of research institutions in this country; that these institutions are pursuing studies among the natives of South and Central America, as well as in Mexico where the versatile Aztecs either possessed or created a unique order of architecture, decorative art, and a wonderfully complicated and as yet practically unsolved system of picture-writing. Some may know of the work being carried on by the United States by the School of American Archæology at Santa Fe, and the Bureau of American Ethnology, under the Smithsonian Institution at Washington; the researches of both, to a great extent, concern the Indian and the various forms of study pertaining to a comprehensive knowledge of his race. But, few indeed, have knowledge of the fact that in our recently admitted State of New Mexico, there is a monument which is memorial to another race, a great race whose history bears pertinently on the discovery and early attempts to colonize this country. Naturally it is the Spaniards, those strikingly shrewd and bold soldiers who strove so fearlessly to subject and christianize the inhabitants of the southern parts of North America, to whom these records pertain. Of prime interest then, is the great natural fortress-like rock which stands a time-defying monument, a literal page of history. Unlike most ancient monuments, instead of a ruin, it is practically intact; another valuable feature is that no excavation is necessary, and further, the "monument" can in no way be moved, but will stand for eternity in its original position bearing for posterity with vivid exactness and authenticity the legends and signatures of the earliest white explorers and campaigners of the United States.

This great rock looks like a castle and was known as such by the first Spaniards, who named it El Morro. It raises its titanic and rugged mass majestically from the mesa-broken plains of an almost unknown corner of New Mexico, some fifty miles southwest from Grant's Station on the Atlantic and Pacific Railroad. It is approachable only by a rough and hard trail; one leaves the station and travels up and down the slopes of the Zuñi Range, through extensive forests, over a plateau bounded by old volcanic cones and grim craters, and carpeted with broad patches of dismal lava, down an attractive valley which is bounded on the one hand by tall mesas of variegated colors, and on the other by forests of pines. The route coincides closely with the old trail from Zuñi to the Rio Grande, blazed years ago, but now nearly lost except at points where nature permits no other passage, and, hence the direction known, the path of the modern traveler follows that of the earliest adventurer in these parts. Well down the valley standing sedately among the other mesas which it dwarfs, a great wedge-like sand stone mesa spreads out into the valley, its front edge rising for two hundred odd feet straight and shear, its rear stretching away in a decreasing slope for nearly half a mile to the main plateau.

One glance suffices to accord its name. The face of this Gibraltar-like fortress of rock suggests nothing so readily as a medieval castle; built firm and solid basically, and stretching aloft, its eroded sides resemble rough hewn battlements with deep-cut recesses and projecting bastions. Its crown of spire-like peaks, a veritable citadel, is the first point of the landscape to be bathed by the blazing rays of the early sun, while at night the final glories of the dying day seem to enfold it tenderly in golden splendor. There it stands, grimly dignified, severe and almost awe-inspiring in its outline, repelling, as it were, the onward march of progress, and actually defying the ages through which it has passed, bearing its messages to modern eyes, and for the years to come.



Photograph by the Bureau of American Ethnology of the Smithsonian Institution.

A. One of the More Modern Inscriptions; Lieut. J. H. Simpson and the Artist, R. H. Kern, 1849. B. The Modest Signature of the Soldier Felipe de Arellano, Who Did Not Record the Year of His Visit.

About the base is a camping site made secure by the protection its walls afford from cold and storms, but lacking in water. Once, however, it was a necessary stop for travelers, being watered by a clear spring which flowed from out of the rock. That it has served for camps these many years is readily noted and understood, all about the smooth sandstone of its foot there are cut deep and clear inscriptions, signatures and historical messages from the hands of the earliest explorers down to those of present-day tourists. It has been christened for this reason Inscription Rock and by this name is perhaps better known to the few Americans who have seen it than by any other. The inscriptions date from 1606, making this undoubtedly the most valuable historical reference book on this continent. Mr. Charles F. Lummis in his interesting book "Some Strange Corners of Our Country," has appropriately chosen "The Stone Autograph Album" as a new name for this remarkable rock. The inscriptions are far more readily translated than similar records of other early nations.

One must, however, be a good student of Spanish, old Spanish, too, for the inscriptions are in the language of the authors, quaintly and oddly abbreviated in an unusual short-hand practically unknown to modern linguists. Nevertheless, the legends have all been solved and rendered into English, including some which proved enigmas for a time, comparable to the hieroglyphics of the Old World's treasured tablets of stone and manuscripts of papyri. There are the names of at least twenty significant Spanish explorers, readily discernible, although the modern American pseudo artists and writers have done some damage by adding their names to those of the country's early heroes.

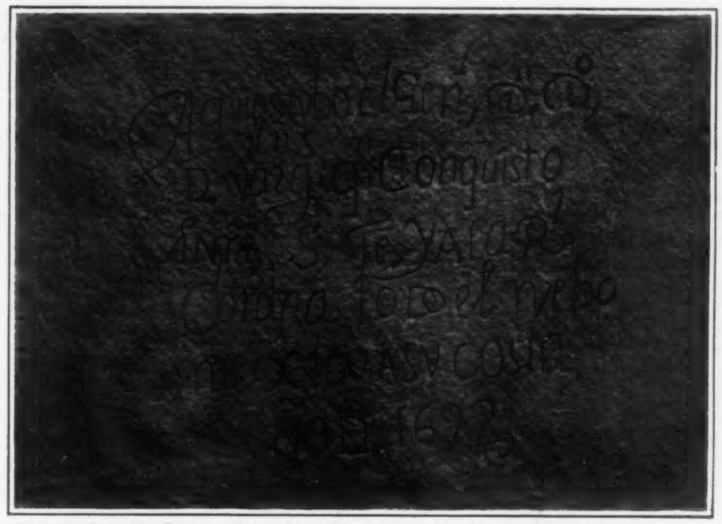
It is not thought that the Spanish conquerors recorded their names and achievements with anything akin to vanity nor with a desire for notoriety, but as a matter of record, as a single blaze in the trails beset with peril, which they followed back and forth during the stormy ups and downs of their occupancy of what is now New Mexico. They put their hands and seals to the deeds accomplished and the honors won for the Royal Crown. It was no pleasure jaunt that these intrepid conquistadores undertook in a country where the enemy greatly outnumbered their tiny parties, and where, at any time, their hand-carved inscriptions might have to serve as their own epitaphs. They waged a one-sided war in the enemies country where none but the brave dared venture, and they well deserve greater praise than is shown by their modest statements.

The earliest inscription, and historically the most important is that of Juan de Oñate, colonizer of New Mexico, and founder of two cities; of San Gabriel de los Españoles in 1598, the second oldest town in the United States, and of Santa Fe in 1605. It was seemingly in the next year that Oñate, on his return from a trip to the Gulf of California camped at El Morro and carved the inscription: "Passed by here the (officer) Don Juan de Oñate from the discovery of the South Sea, April 16th, 1606," although other contemporary records give 1605 as the date of this exploration.

One inscription is apparently older than the above but it cannot be positively identified. It is that of Pedro Romero and the date seems to read "17,580," the first figure, however, is no doubt the Spanish *y* or *i*, indicating "and," used before dates not infrequently at this time,

Photograph by the Bureau of American Ethnology of the Smithsonian Institution.

The Inscription by Don Juan de Oñate, 1606, Showing Also Old Indian Carvings, and Modern Marks.



Photograph by the Bureau of American Ethnology of the Smithsonian Institution.

The Legend of Don Diego de Vargas, 1692, a Spanish General Who Conquered All of New Mexico.

while the "7" is probably the old Spanish "1." Following this line of reasoning the date is "1580" which seems to indicate that Romero was one of the companions of Francisco Sanchez Chamuscado who is known to have passed this point in that year.

A little way along the great wall of stone there is a neatly written statement and autograph of Don Diego de Vargas, a general of Spain who had a generous and philanthropic nature who in 1692 successfully, but at frightful cost, reconquered the Pueblo Indians after their revolt in 1680. His legend translated reads:

"Here was the General Don Diego de Vargas, who conquered for our Holy Faith, and for the Royal Crown, all of New Mexico, at his own expense, in the year of 1692."

Adjacent to the Vargas legend is a note concerning the expedition sent to arbitrate with the Zuñi Indians by the Governor Francisco Martinez de Baeza (of Mexico). This inscription is headed by a cross as are several of the writings and reads as follows: "We pass by here, the sergeant-major, and the Captain Juan de Arechuleta, and the lieutenant Diego Martin Barba, and the Ensign Augustin de Ynojos, year of 1636."

It is noted that the sergeant-major is not named, but it is probable that he was none other than the brave Francisco Gomez. The carving is supposedly by the hand of Diego Martin Barba, official secretary to Governor de Baeza, to judge by the form of the characters. Near at hand is seen the inscription: "Juan Garsya, 1636," and since it is known that he was a member of this party, these two inscriptions seem to verify each other. The Ensign of the party must have been dissatisfied with having his name cut by the Lieutenant, for in several places the name Ynojos appears in the form of a fine autograph. There follows an inscription by a common soldier who did not record the year of his visit, but was subsequently killed by the Zuñi Indians in 1700 while serving as one of a garrison of three. His writing forms two lines and reads:

"I am from the hand of Felipe de Arellano, on the 16th of September, soldier." Like the legend inscribed by Lieutenant Barba, that of the soldier Arellano, bears over it the cross which differs only by the double vertical lines. His statement is concluded by a long horizontal line, terminating in a grotesque rubric.

Just above his brief lines is a sample of the more modern record, so placed, however, as not to injure the ancient writings surrounding it. It is that of Lieutenant J. H. Simpson, U. S. A., and R. H. Kern, an artist, who spent two days at El Morro in 1849, reproducing its inscriptions.

Early in September, 1911, Mr. Frederick W. Hodge, ethnologist in charge of the Bureau of American Ethnology of the Smithsonian Institution, visited El Morro, where with the assistance of Mr. Jesse L. Nusbaum of the School of American Archæology at Santa Fe, photographs of the rock and its inscriptions were made, and paper impressions of the inscriptions were taken. In taking the impressions a special form of moistened blotter-like paper was employed. The reproductions called "squeezes" were, of course, in the "negative" but from them casts were made in plaster which gave the "positive," and from exact facsimilies of the orginal carvings on the rock. The "squeezes" have all been cast, and the reproductions are now deposited in the United States National Museum, at Washington, where they will eventually be put on public exhibition.

Although this great History Book of ours has recently been made a National Monument by proclamation of the President, there is no local custodian and consequently all its remarkable inscriptions are constantly exposed to vandalism. The writings of the early explorers, so valuable to the history of the early Southwest, are ever threatened with destruction by the thoughtless visitors who scratch their comparatively insignificant names in dangerous proximity to these old irreparable records of original exploration. It is hoped that ultimately the site of El Morro may be placed in the care of a keeper, and converted into a sort of local museum where the "Hands Off" sign may be displayed and its complete significance enforced.

Scientific Incendiarism

Ingenuity Applied to Evil Purposes

In Southern California where the hills are covered only with "chapparal" or brush, the stockmen have used them for their flocks and herds for over a century. These pioneer stockmen found that by burning off the brushy covering of these hills, they could obtain several years of excellent feed, while five or six years of no fires and the brush reached a density and height through which no grazing animal, not even a goat, could make their way. So there grew up the practice of frequently burning off these brushy areas that their herds might the better graze over them.

Photograph Taken from Overhead: The Lens and Supporting Wire only Dimly Discernible. Their Shadow Shows up More Clearly, as Indicated by the Arrow.

Along the western slope of these mountains, and depending on them for every drop of water with which to irrigate the lands, lies one of the garden spots of the world, the orange-growing district of Southern California.

Here, water for irrigation commands the highest value of any place on the globe. Every drop is needed, every drop must be saved, and the brush covering these hills is the sole means of saving the snow and rainfall and keep it from running off in floods into the nearby Pacific.

Thus it was that many of the stockmen resented the coming of the Forest Rangers who stopped the wholesale burnings, and where the fires did get started, fought them day and night till they were out.

The burning of a brush covered mountain may seem a small matter, but of all the fires which a forester has to combat, a brush fire is the worst.

For these reasons, when a series of brush fires occurred in a certain district in Southern California, for the origin of which no reasonable excuse could be found, the forest officers set diligently to work to discover the source. They saw the effect—and eventually found the cause.

One red hot summer day a fire broke out on a mountain side where the brush was thickest and conditions for a fire almost ideal. There had been half-a-dozen smaller fires in this immediate vicinity but, although after each was out they made the most careful investigation, not a thing could they find to which they could tie a reliable suspicion as to its genesis.

After the last fire, the forest officer in charge of the district started in to make a systematic search of every foot of the area about where it was known to have originated, to see if he couldn't find something on which to build up some theory or suspicion as to its start.

It was not lightning, for it had not rained there for six months. It was not campers, for no sane person would camp in such a spot. It was not sheepherders,

This is How the Culprit's Ingenious Device Appears When Clearly Exposed Against a White Background. Note the Matches Scattered on the Ground in the Field of the Lens.

for a chipmunk was about the only animal that could worm its way between the dense treelike bushes. Nor was it a locomotive—that commonest of all sources of forest fires—for there was not a foot of railroad within thirty miles. This exhausted the list of ordinary causes. He must look further for the reason.

Like a blood hound on the trail this man followed the edge of the burned over area. Hour after hour he crawled along, bent almost double, his eyes watching every inch of ground over which he passed. Finally he came to a little piece of fencing wire, some ten inches long, stuck into the ground at an angle of about forty-five degrees. At its upper end was a small loop in the wire about the size of a silver half dollar.

He sat down in the black dirt and studied that piece of wire for half an hour. Every inch of the ground about it was scrutinized and gone over as if with a fine toothed comb, in an endeavor to connect the wire with the fire—the possible cause with the certain effect.

All he found was a little hole scooped in the ground directly under where the loop in the wire came, as it stood up in the ground. In this hole were a few minute particles of glass, and some ashes, unlike the ashes made by the burning brush.

Then he saw a great light. He resumed his search more carefully than ever and a hundred yards from there, under a tall bush, in a little island of unburned brush, he found another piece of wire attached to a lens or glass taken from a pair of common spectacles or eye glasses. One end of the wire was in the ground, the other with the glass was in the air. Directly under this glass, which made a most effective burning glass, was a little hole scooped out in the earth and in it a block of California matches nested down amid a lot of fine dry grass, bits of dry wood and other inflammable material, all so placed as to quickly carry any fire in them to the surrounding brush and grass.

It needed no Sherlock Holmes to tell this forest officer what the whole affair meant. Given a bright Southern California day, in the month of August, a lens for a burning glass and a bit of inflammable material to catch the heat of the sun concentrated on it through the lens and the whole plan was perfect.

But evidently the plans of the cunning incendiary had gone wrong for this second fire trap had failed to work at the critical time, leaving it here a silent but effective witness to his ingenuity.

Wise in his generation was this forest officer. Not a step did he take or a thing did he touch in the vicinity of this unsprung "fire trap." Hastening to his station, he returned with witnesses and a camera lest his evidence might not be accepted when the time came.

Later on, the boasting of a certain person that he "could start a fire in the hills and be miles away from it at the time," gave a faint clew which, followed up carefully, led to his arrest. One day this individual found himself facing a United States judge in Los Angeles who was asking him if he knew of any reason why he should not pronounce sentence upon him for starting a fire upon Government lands.

Evidently his reasons were not satisfactory for the man eventually found himself located in the county jail with six long months ahead of him in which to study over the changed conditions concerning the use of the hills and mountains for bonfire purposes. Incidentally, also, the judge asked him to contribute the sum of $500 to the public treasury as a slight recompense for the trouble he had caused his Uncle Sam.

Geared Turbines*

Their Development for Ship Propulsion

By George Westinghouse

I HAVE read with interest the article by Sir W. H. White[1] on geared steam turbines and their development for ship propulsion.

The great problem before governments and owners of steamships, as well as naval architects and engineers, is the production of propelling machinery which will be highly efficient, economical in space and weight, free from objectionable noise and vibration, durable in operation, and which can be readily repaired aboard ship, the latter being a feature of special value in naval service.

Sir William's article completely confirms the conclusion reached by Admiral George W. Melville and Mr. John H. Macalpine in their report to me in May, 1904, made after a prolonged investigation of the question involved, in which they said:

"If one could devise a means of reconciling, in a practical manner, the necessary high speed of revolution of the turbine with the comparatively low rate of revolution required by an efficient propeller, the problem would be solved and the turbine would practically wipe out the reciprocating engine for the propulsion of ships. The solution of this problem would be a stroke of great genius."

INTRODUCTION OF GEARING.

After the delivery of his report Admiral Melville, who had fifty years previously been an engineer on a United States warship fitted with gearing to increase the speed of the propeller, argued in favor of the use of speed-reducing gearing between turbines and propellers as a possible solution of the problem; but after prolonged discussions he finally agreed with me that something new was required to meet the difficulty of first establishing and then maintaining a perfect tooth contact of uniform pressure in gearing having fixed bearings and the length of teeth needed for the large powers demanded in the equipment of modern naval and merchant vessels.

In 1906 Admiral Melville and Mr. Macalpine came to me with drawings of the floating frame arrangement which they had evolved. As the design seemed to meet the necessities I immediately agreed to undertake the construction of the gearing, which was finally completed and tested in 1909. Patents were granted in several countries for the invention, British Patent No. 18,759 of 1907 having been opened to public inspection on February 23rd, 1908.

I am safe in saying that prior to my bringing out the Melville and Macalpine reducing gear with its self-aligning floating frame, engineers generally, not excluding Sir Charles Parsons, who had already achieved a world-wide eminence in marine work, had but little faith in the use for marine work of such gearing as was then known.

It must not be overlooked that there had been little or no experience with large gears moving so rapidly as those of Melville and Macalpine, so that when a pitting of the teeth near the pitch line developed (a difficulty mentioned by Sir Charles Parsons in describing the operation of the "Vespasian's" gears) the cause and a cure had to be worked out to insure durability. A careful study of this difficulty satisfied me that the cause of the pitting was due to the teeth coming together at a velocity of 100 feet per second with a hammer effect. The cure was to substitute a pinion frame hydraulically and elastically aligned in place of the original floating frame. In my judgment, one familiar with the simplicity and effectiveness of this hydraulically adjusted pinion frame would no more think of resorting to an arrangement of gearing in fixed bearings than of attempting the impossible arrangement of rigidly fixed bearings for a locomotive running at high speed upon an uneven surface.

British Patent No. 18,759 of 1907, with its specification and drawings covering the Melville and Macalpine invention, was, as stated, available to Sir Charles Parsons months before he delivered his James Watt Anniversary Lecture at Greenock, Scotland, on January 15th 1909, in which he said:

"We might naturally speculate as to the future, and inquire if there is a possibility of the turbine being constructed to run more slowly and without loss of economy, or whether the propeller can be modified to allow of higher speed of revolution. Or, again, may the solution be found in reverting to some description of gearing—not the primitive wooden spur gearing of half a century ago but to steel gearing cut by modern machinery with extreme accuracy and running in an oil bath, helical tooth gearing, or chain gearing, or again, some form of electrical or hydraulic gearing? These are questions which are receiving attention in some quarters at the present time, and if a satisfactory solution can be found, then the field of the turbine at sea will be further extended."

This clearly indicates that he had not yet reached any conclusion in the matter of the use of reducing gear; and I am sure Sir William White will agree that the experiment made by Sir Charles Parsons in 1897 with a 10 horse-power geared turbine has no more to do with the questions under discussion than the fact that I made and operated a jet steam turbine in 1870 has to do with the subsequent work of others.

Prof. Biles, in his paper read before the Institution of Naval Architects, March 29th, 1912, a portion of which was published in *Engineering* of April 12th, with illustrations, says in regard to early gear work by De Laval, whose work on turbines and gears antedated that of Sir Charles Parsons:

"De Laval showed how gearing could be successfully applied in his turbine, which runs at many thousands of revolutions per minute. The Westinghouse Company have applied helical gearing to large powers on the Melville and Macalpine system. Sir Charles Parsons tried gearing in connection with his earliest turbines, but did not continue its use, preferring the disadvantages of the small screw in marine work to those of the gearing."

I mention these details particularly because of the bearing they may have on the question as to those most entitled to credit for initiating the use of modern reducing gears in connection with marine turbines.

SOME COMPARATIVE RESULTS.

Sir William refers to particulars given by Prof. Biles of the two cross-Channel steamers in the service of the London and South-Western Railway fitted with Sir Charles Parsons's latest turbines and gears, and states that this is "one of the most important and most recent applications of the geared system." I am thus afforded an opportunity to make comparisons based upon these particulars which will bear out the claims I make as to the imperative need in large powers for the use of a floating frame which will not only maintain an even tooth pressure in order to effect a great reduction in the weight and cost of the gear apparatus for the operation of vessels, but which will also reduce vibrations and consequent noise to a minimum.

The illustrations accompanying Prof. Biles's paper show that the installations in the "Normannia" and her sister ship comprise two sets of compound turbines of the usual type manufactured by Sir Charles Parsons, each having a high and a low pressure rotor, each turbine operating a shaft with pinions engaging in the main gear connected to the propeller shaft. There are therefore four pinion shafts to carry the 6,000 horse-power maximum developed on the trials; that is to say, 1,500 horse-power per pinion shaft.

In the "Vespasian," first tried in 1910, the maximum power developed did not exceed 1,000 horse-power. In this case there were also a high and a low pressure turbine each driving a pinion, so that the maximum work done per pinion was only 500 horse-power.

In the case of the U. S. collier "Neptune," with reduction gears fitted with my own hydraulically operated floating frame, there are only two turbines and two pinions, each of which developed a maximum of 4,000 horse-power on trial. The work done per pinion on the "Neptune" was therefore about 2 2/3 times the greatest work done per pinion on the "Normannia," which is the largest Parsons installation of which any account has been given.

In the test of the Melville and Macalpine trial apparatus by the Westinghouse Machine Company in November, 1909, a continuous 40-hour run was made at 6,000 horse-power, while a maximum of 6,800 horse-power was obtained, making the work of the pinion more than four times that of the greatest work done by the Parsons pinion on the "Normannia."

It would appear, therefore, that Sir William, in the concluding paragraph of his article, overlooked the fact that the maximum gear work on the "Normannia" is divided between four pinion shafts, and that such work is not of great importance, because the greatest power transmitted by one pinion shaft of the largest Parsons installation does not exceed 1,500 horse-power, while the gearing on the "Neptune" does have very great importance in considering the problem of applying reduction gearing for large powers such as are required for battleships, cruisers, and trans-Atlantic steamers.

If the amount of expenditures such as that referred to by Sir William in connection with the purchase and fitting of the "Vespasian" can have any weight with those whom we both desire to impress, then the much greater expenditures of time and money of the Westinghouse Machine Company and myself in the development and trial of reducing gears should be impressive.

Three years ago I cheerfully gave to the world through the technical press a full account of the trials of the reducing gear apparatus made by the Westinghouse Machine Company with the drawings and description of the special and costly apparatus employed to determine with great accuracy the power transmitted as well as the losses in transmission. These particulars were so complete and full that further tests to determine loss in transmission seem to be unnecessary.

TOOTH PRESSURES.

The admirable operation of the hydraulic floating frame has established the fact that in gears of 1,000 to 2,000 horse-power a maximum tooth pressure of 1,000 pounds per lineal inch of gear width is a safe working pressure, for it must be borne in mind that this 1,000

*Engineering Supplement of the London *Times*.

[1] See SCIENTIFIC AMERICAN SUPPLEMENT, November 23rd, 1912, p. 323.

pounds is divided practically between two teeth, making the maximum pressure per inch of tooth about 500 pounds. If this be so, no great difficulty could have arisen due to excessive tooth pressure on the "Vespasian" even if the axes of the two gears were not exactly in line, because if even only one quarter of the total length of teeth were to be engaged, there would not result an abrading pressure, and this would also be the case with respect to the gears installed upon the "Normannia" and other ships fitted in a like manner. Stated in practical terms, the width of main gears and length of pinions in the "Vespasian" and "Normannia" are more than double the requirements when absolute uniform tooth pressure is automatically assured. It would therefore seem that the Parsons reducing gear with rigid bearings has not yet undergone the test of the high tooth pressure at high speeds which must eventually be provided for, and that Sir Charles Parsons's success has been in avoiding such pressures by making heavy and costly apparatus rather than in producing the lighter gearing rendered possible by the hydraulically aligned pinion frame.

Realizing, in the interest of marine work, the high importance of quickly and conclusively establishing the practicability of the floating frame as well as the probable life of high speed high power pinions, I have had constructed since 1910 twenty sets of reducing gears with an aggregate capacity of 29,000 horse-power used for driving electric generators and pumping apparatus. There are now under test two gears of 6,000 horse-power each, and a number of other sets are under construction making an aggregate of about 50,000 horse-power. Some of these gears have run with 100 per cent overload for long periods and others have had excessively severe and rapid fluctuations in load from a few per cent of full load to over 100 per cent overload. The service of some of these gears measured by speed of the teeth and the work performed, with a negligible amount of wear, if employed in marine work would drive a vessel like the "Vespasian" over 200,000 nautical miles, which has satisfied my engineers that the life of high-speed gearing with the hydraulic floating frame will be much greater than the life of any ship to which these gearings may be fitted.

In regard to the gears on the "Neptune," Lieut. W. W. Smith, U. S. N., the chief engineer of that vessel, says in a paper published in the *Journal of the American Society of Naval Engineers* for August, 1912:

"In the writer's opinion, the floating frame or similar device for aligning the pinion automatically is absolutely essential for large gears. Ship's mechanics could not be relied upon to make the extremely accurate alignment that would otherwise be required. For military reasons it is of great importance to be able quickly to overhaul and assemble with the absolute assurance that the machine will run perfectly and be absolutely dependable. This feature of the floating frame is of utmost importance in naval work, where self-maintenance and reliability are essential. With the floating frame it is only necessary to adjust the struts according to the plug gages, which any mechanic of ordinary ability can do. The alignment takes care of itself.

"There has been practically no wear. The pinion teeth are highly polished and show no signs of cutting. The gear teeth are barely polished along the patch line."

It is obvious that rigidly carried gears must be cut and dressed with great accuracy before they are put in service, and the scraping of the teeth is a tedious and expensive operation. The pinions and gears of the hydraulically operated system can be inserted in their bearings just as they come from the cutting tool, and in this condition will operate satisfactorily and without objectionable noise.

Assuming, however, that Sir Charles Parsons will succeed in producing rigid reducing gears capable of handling powers very much larger than those with which he has so far dealt, it is obvious that, in addition to the greater facility with which gears and pinions for use in hydraulically supported bearings may be produced, the hydraulic support provides an additional factor of safety in operation which is of great importance.

Another most important feature of the reducing gears with hydraulic bearings is the direct indication given by the pinion of the work being done by the gear at any given moment.

I have very high appreciation of the work Sir Charles Parsons has done in the development of marine turbines and an equally high opinion of Sir William White's knowledge of this interesting subject, and I believe we must be in accord in desiring to have brought out all of the advantageous points in connection with the use of geared turbines for marine work.

Crystal Structure Revealed by Röntgen Rays*

A Glimpse of the Molecular Architecture of Solids

By B. E. H. Tutton

DURING a visit to Munich at the beginning of August last the writer was deeply interested in some extraordinary photographs which were shown to him by Prof. von Groth, the *doyen* of the crystallographic world, and professor of mineralogy at the universiry of that city. They had been obtained by Dr. M. Lane, assisted in the experiments by Herren W. Friedrich and P. Knipping, in the laboratory of Prof. A. Sommerfeld in Munich, by passing a narrow cylindrical beam of Röntgen rays through a crystal of zinc blende, the cubic form of naturally occurring sulphide of zinc, and reciving the transmitted rays upon a photographic plate. They consisted of black spots arranged in a geometrical pattern, in which a square predominated, exactly in accordance with the holohedral cubic symmetry of the space-lattice attributed by crystallographers to zinc blende.

Prof. von Groth expressed the opinion, in agreement with Herr Lane, that owing to the exceedingly short wave length of the Röntgen rays (assuming them to be of electromagnetic wave character), they had been able to penetrate the crystal structure and to form an interference (diffraction) photograph of the Bravais space-lattice. This latter is the structural foundation of the more complicated regular point-system according to which the crystal is homogeneously built up, and the points of which (the point-system) represent the chemical elementary atoms. The space-lattice, in fact, was conceived to play the same function with the short-wave Röntgen rays that the diffraction grating does to the longer electromagnetic waves of light.

The details of this work were laid before the Bavarian Academy of Sciences at Munich in two memoirs, on June 8th and July 6th last, and the two memoirs are now duly published in the *Sitzungsberichte* of the Academy. Besides a diagram of the apparatus, which is reproduced in Fig. 1, they are illustrated by reproduction of a dozen of these photographs, one of which is also reproduced in Fig. 2. There can be no doubt that they are of supreme interest, and that they do in reality afford a visual proof of the modern theory of crystal structure built up by the combined labors of Bravais, Sohncke, Schoönflies, von Fedorow, and Barlow. Moreover, they emphasize in a remarkable manner the importance of the space-lattice, so strongly insisted on from theoretical considerations by Bravais, Lord Kelvin, and von Groth, and from experimental considerations by Miers and the writer. They further confirm the structure assigned to this binary compound zinc sulphide, ZnS, by Pope and Barlow. Incidentally they may form a crucial test of the accuracy of the two rival theories now being discussed as to the nature of X-rays, and the wave theory.

Out of an excellent crystal of zinc blende a plate was cut a centimeter square and half a millimeter thick, parallel to a cube face (100), that is, perpendicular to one of the principal cubic crystallographic axes of the crystal (a tetragonal axis of symmetery). The plate was supported in the usual manner on the crystal holder of a goniometer and precisely adjusted so that a beam of Röntgen rays one millimeter in diameter impinged perpendicularly upon it, after passing first through a series of screens to eliminate secondary radiations from the glass walls of the Röntgen tube. The last screen, which gave the final form to the bundle of rays, was a plate of lead a centimeter thick, pierced by a cylindrical hole 0.75 millimeter in diameter, and fitted with a delicate means of adjustment so that the axis of the boring could be brought exactly perpendicular to the crystal plate. The beam of pure Röntgen rays of circular section thus passing through the crystal normally was received, also normally, on a Schleussner-Röntgen photographic plate, which was subsequently developed with rodinal. The time of exposure in different experiments varied from one to twenty hours, the whole apparatus being excluded from all ordinary light by a covering box.

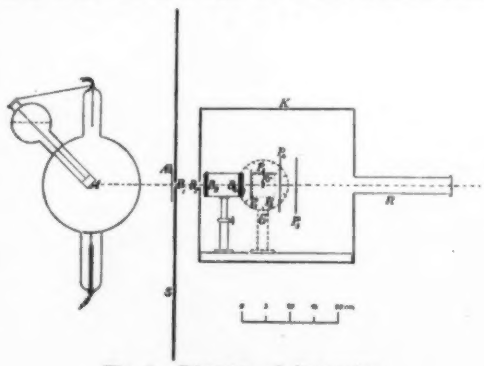


Fig. 1.—Diagram of Apparatus.

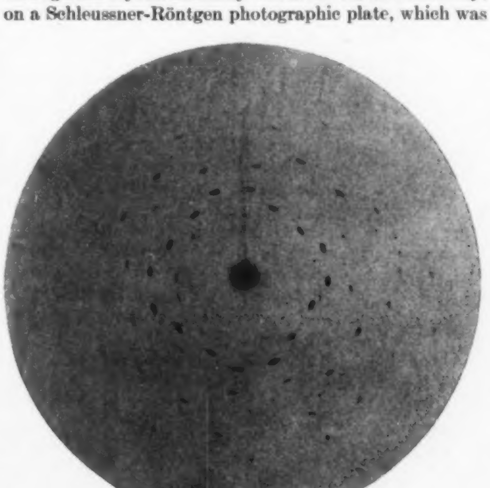


Fig. 2.—Pattern Obtained by Allowing X-rays to Pass Through a Crystal of Zinc Blende on a Photographic Plate.

The positive print, reproduced in Fig. 2, from the negative thus obtained shows a central black spot, about half a centimeter in diameter, surrounded symmetrically by sixteen smaller black spots of about the same intensity, but of elliptical shape (about two millimeters long), arranged in a diagonally (diamond-wise) placed square, four spots being on each side of the square and separated from each other by about half a centimeter, the center of the square being exactly occupied by the large spot already alluded to, which was caused by the direct rays. Outside the square of spots were others of a fainter character, also arranged with similar cubic symmetry, and there was also a faint square of spots inside the intense square, nearer to the latter than to the large central spot.

* Reproduced from *Nature*.

Human Happiness a Business Asset

HUMAN life is gradually becoming recognized as a business asset. This is a new fact in the development of the race. Life-insurance companies are realizing that they can increase their dividends faster by cutting down the death-rate than by increasing sales or by reducing expenses. Employers of large numbers of human machines are realizing the surprising fact that, as a cold business proposition, it pays, not in sentiment but in dollars, to take good care of their employees. Business men are learning that well-fed, well-clothed, contented men and women, working in well-lighted, well-ventilated quarters and on schedules arranged in accordance with our modern knowledge of psychology and physiology, actually turn out more work and better work than underpaid, discontented help, working under uncomfortable and insanitary conditions. Therefore, large corporations are spending money liberally in playgrounds, rest-rooms, libraries, gymnasiums, sanitary lunch rooms, moving picture shows, safety devices, ventilating systems and similar devices for the well-being and enjoyment of their employees. If one asks these men why they are doing these things, they will disclaim any charitable or philanthropic motives. "This isn't charity," says one firm, "we want that clearly understood. This is simply good business management and common sense. A well man is of more use to us than a sick man. A happy, contented woman turns out more work and better work than an unhappy one. Therefore anything we can do to make the people who do our work at ease in mind and body we regard as good business management, just as we regard fire-insurance, improved machinery and labor-saving devices." The firms that have realized the enormous importance of this discovery are already reaping the benefits. The conservation of the health of employees will be a fundamental principle of good business management in the future.—*Journal Am. Medical Association.*

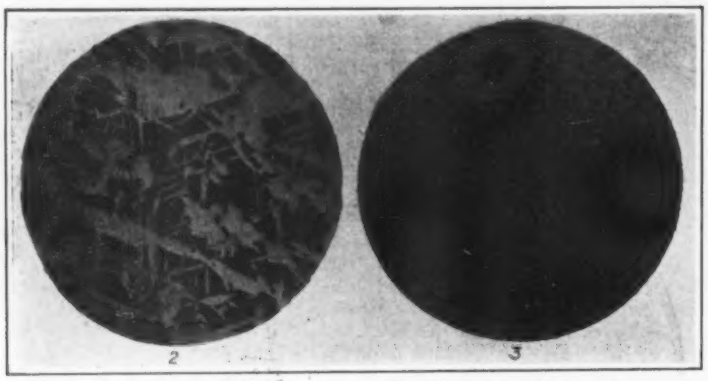
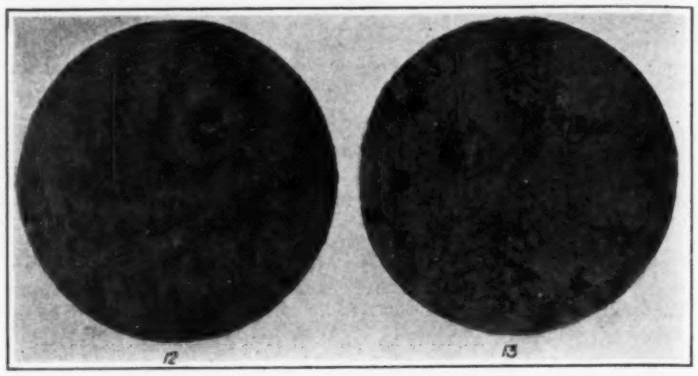


Fig. 2.—Original Microstructure of the Ordinary Carbon Frames.

Fig. 3.—The Microstructure Obtained by Quick Cooling.



Figs. 12 and 13.—Microstructure of Bottons Located at Correspondingly Numbered Points in the Lower Frame of Fig. 1.

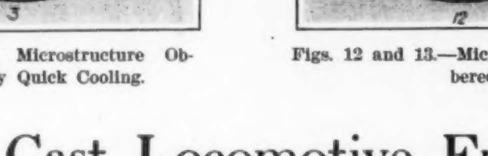
Steel Cast Locomotive Frames*

The Importance of Heat Treatment—High Carbon, Vanadium and Nickel Castings Considered

By Edwin F. Cone

The manufacture of steel cast locomotive engine frames in the United States has assumed proportions that are realized by very few people. Twenty years ago nearly all the locomotives were supplied with engine frames forged from wrought iron and the prejudice against those made of steel castings was very decided. To-day it is probable that at least 95 per cent of the locomotives made by the two large producing companies are supplied with steel cast frames and at least 80 per cent of these are produced in what is known as the Chester, Pa., district, where there are seven large steel foundries, a large part of the output of which consists of locomotive engine frames of all sizes, weighing from 1,000 to over 10,000 pounds each.

The early prejudice against steel cast frames was due largely to the comparatively poor product made in the early stages as compared with that made now. Steel foundry practice has been developed to such an extent that locomotive frames are now produced which equal or excel any forged frame ever made, not only in endurance in service, but in physical and chemical qualities also. There have been improvements in methods of molding, in the quality of the metal, and more especially in the heat treatment of such frames. Briefly, the general practice is to mold the frames from a pattern of wood in a long flask, using the usual foundry sand mixtures. The molds are then thoroughly dried in suitable ovens and



Sections: At A, 4½ x 4½ In.; At B, 3⅝ x 4½ In.; At C, 6 x 4½ In.; At D, 4½ x 4½ In.; At E, 4½ x 6½ In.; At F, 4⅜ x 4½ In.; At G, 4⅜ x 4½ In.; At H, 4¾ x 6½ In.

Fig. 1.—Frames for Locomotives Cast of Steel.

after being fitted up are supplied with metal from acid open-hearth furnaces of about 25 tons capacity, some foundries in the Chester district pouring as many as eight to ten frames per day. The method of molding and pouring varies in each foundry, as also, in particular, the method of heading and gating. And the producer of frames who is the most successful is the one that has the best methods of pouring and molding and the best metal.

The chemical and physical properties of these frames are about the same, no matter by what foundry produced. With the exception of one foundry in the Chester district, they all use acid open-hearth steel. The average chemical composition of all ordinary carbon engine frames is as follows: Carbon, 0.25 to 0.30; manganese, 0.65 to 0.70; silicon, 0.25 to 0.30; sulphur, 0.030 to 0.040; phosphorus, 0.025 to 0.035.

By ordinary carbon is meant all frames as distinguished from high carbon, such as 0.38 to 0.42 per cent carbon, and also vanadium steel cast frames. Of late there has been some demand for a higher carbon frame whose composition is the same as that mentioned above except that the carbon content is 0.38 to 0.42 per cent, with a relatively higher tensile strength running from 80,000 to 90,000 pounds per square inch, with a correspondingly lower ductility. Whether this is an advantage or not over the lower carbon frame is a matter of some dispute. It would seem that it would be more liable to breakage from shock than the more ductile and milder steel, but a test in service should determine this point in due time, one railroad in particular in the East having a large number of engines equipped with these high-carbon frames.

Those advocating the use of 0.40 per cent carbon frames claim that the extra strength is needed because of the heavier weight resulting from larger boilers and upper structure, and that the deleterious effect of shock can be overcome by suitable springs. There is a fact in this connection, however, that must not be overlooked, i. e., that all high carbon steel castings have a tendency to be more or less "blowy," no matter what precautions are taken in producing the metal. High carbon metal is wilder and more active when tapped than the ordinary lower carbon, and there are many who insist that this is an element of weakness in the frames, which, combined with a greater tendency to brittleness, renders them less desirable. The harder frames seem to be growing in favor, however, the demand for them increasing every year. The relative physical properties of these two kinds of frames are here tabulated:

PROPERTIES OF TWO CLASSES OF LOCOMOTIVE FRAMES.

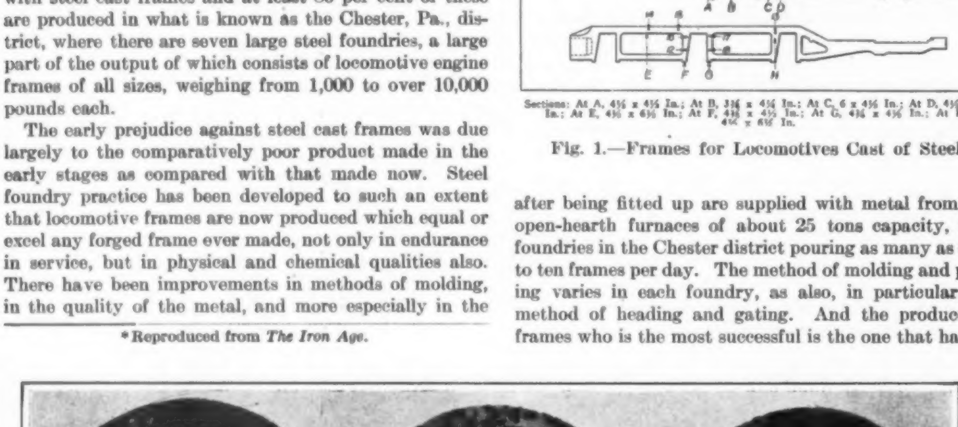
	0.25 to 0.30 Carbon	0.38 to 0.42 Carbon
Tensile strength, lb. per sq. in.	65,000 to 75,000	80,000 to 90,000
Elastic limit, lb. per sq. in.	34,000 to 39,000	41,000 to 47,000
Elongation in 2 in., per cent	25 to 35	15 to 20
Reduction of area, per cent	40 to 55	25 to 35
Elastic limit of tensile strength, per cent	52	52

It is claimed by some that a special heat treatment of the high-carbon steel renders it superior to any other steel for frames.

Many foundries are now also called upon to furnish vanadium steel locomotive frames, and many of the roads are putting them to a careful test and scrutiny. The effect of the vanadium is to raise the tensile strength for the same carbon content by 10 to 15 per cent, and to increase the elastic limit also, with a corresponding decrease in elongation. The average of some 400 tests on engine frames made of annealed vanadium steel with an average vanadium content of 0.18 to 0.20 per cent showed the following results:

AVERAGE OF 400 TESTS OF ANNEALED VANADIUM STEEL CAST ENGINE FRAMES.

Tensile strength, lb. sq. in.	78,014
Elastic limit, lb. per sq. in.	46,842
Elongation in 2 in., per cent	22.26
Reduction of area, per cent	35.89
Elastic limit of tensile strength, per cent	60.03



Figs. 4 to 11.—Microstructure of Bottons Located at Correspondingly Numbered Points in the Upper Frame of Fig. 1.

*Reproduced from *The Iron Age*.

But unless the vanadium steel is properly heat treated, it is a more dangerous steel than the corresponding low-carbon steel frames, having a tendency to be much more brittle when under-annealed or unannelaed than the ordinary, and this also holds true of 0.40 per cent carbon steel. And it is an open question whether special heat treatment of vanadium steel cast frames is not necessary to produce the best and most reliable results. No attempts have been made to use nickel steel cast frames, though the physical properties of nickel steel castings are very superior, having average results about as here represented.

PHYSICAL PROPERTIES OF NICKEL STEEL CASTINGS.

Tensile strength, lb. per sq. in	85,000 to 95,000
Elastic limit, lb. per sq. in	51,000 to 57,000
Elongation in 2 in., per cent	20 to 28
Reduction of area, per cent	35 to 40
Elastic limit of tensile strength, per cent	60

Ordinary careful annealing brings the results without any trouble. Another advantage is the fact that the nickel content of scrap nickel steel is recoverable in the furnace enhancing the value over any other scrap frames.

But no matter what kind of steel is incorporated into engine frames, their annealing or heat treatment is of vital importance. The general practice is, or should be, to place them in a large pit-annealer where they are heated by gas coal, gas or oil, to above the recalescence point, and after being held there a sufficient length of time to penetrate the frame thoroughly from end to end, to complete the transformation of crystalline structure, they are allowed to cool slowly in the closed annealer. While still hot, but at a black heat, they are removed and straightened under a steam hammer or a drop. The best form of annealer is one fired from the entire side and not from the ends, thereby insuring an even heat treatment throughout the frame instead of the ends being heated possibly too high and the centers not enough.

There has always been some question as to how thoroughly an engine frame is annealed. The usual method of judging the annealing is from the fracture of a 3 × 1¼ × 8-inch test bar, cast solid on the frame. If this shows the proper fine structure to the eye it is usually accepted by a railroad inspector regardless of the heaviness of the section of the frame. It is manifest that this does not necessarily determine whether the inside portions have been heated above the recalescence point and relieved of all strains.

At the suggestion of one of the large locomotive companies two frames of different sections and weight were especially cast and annealed by the usual practice. Each frame was then cut up and slabs of 1 inch thickness were cut out. From the center of each slab buttons were prepared for microscopic examination to determine whether the center of each frame was annealed. The drawings in Fig. 1 show frames with the location of the sections of which the photomicrographs were made. Fig. 2 shows the original microstructure of all ordinary carbon frames before annealing, revealing the large pearlite and ferrite crystals, the breaking up of which is so important to relieve the frame of all internal strains. Figs. 4, 5, 6, 7, 8, 9, 10 and 11 represent photomicrographs taken from the centers of the corresponding points in this frame, and show a complete breaking up of the original structure and a thorough annealing throughout the frame—the microstructure one would expect from slow cooling. This shows not only what it is possible to do in annealing frames properly in a suitable annealing furnace but also what ought to be done.

There has been some discussion as to whether the microstructure represented by the photographs is the best or whether that represented by Fig. 3 is more desirable. The latter is considered to be ideal steel microstructure, but it can only be obtained by quick cooling from above the recalescence point. It is therefore an open question whether bringing frames out into the air to obtain this microstructure would not set up unequal strains in such castings of varied thickness of metal and therefore be harmful. Of course, it is recognized that such heat treatment would render the physical results superior to those obtained by the method of slow cooling, but it is probable this advantage would be offset by other disadvantages. At present the almost universal method is the slow-cooling heat treatment.

In the case of the lower frame represented in Fig. 1, which frame is the larger, the buttons taken from the center do not reveal as much as in the case of the other frame. Photomicrographs of points at 12 and 13, Figs. 12 and 13, are characteristic of them all. They are dominated by large ferrite crystals. It is probable that a complete change has taken place, though in large sections of steel castings it is difficult to determine this because of segregation. Large cross sections of these frames polished and then etched in acids reveal a marked freedom from porosity in any part.

In addition to the microscopic tests, there was cut from each frame an 8-inch section of the rail. From this physical tests were made of the drag and cope sides as well as one from the center for comparative results.

PHYSICAL TESTS TO SUBSTANTIATE THE MICROSCOPIC TESTS.

Lighter or upper frame represented in Fig. 1.

Analysis

Carbon	0.28
Manganese	0.66
Silicon	0.285
Sulphur	0.044
Phosphorus	0.039

	Drag	Center	Cope
Tensile strength, lb. per sq. in	76,000	73,500	77,000
Elastic limit, lb. per sq. in	42,000	39,000	41,500
Elongation in 2 in., per cent	26	19	23
Reduction of area, per cent	38.8	24.1	43.1
Fracture	Silky ½ Cup	Silky	Silky ½ Cup

Heavier or lower frame represented in Fig. 1.

Analysis

Carbon	0.24
Manganese	0.66
Silicon	0.271
Sulphur	0.044
Phosphorus	0.039

	Drag	Center	Cope
Tensile strength, lb. per sq. in	66,000	62,700	65,800
Elastic limit, lb. per sq. in	36,000	34,000	34,700
Elongation in 2 in., per cent	33	15	33
Reduction of area, per cent	53.3	32.2	52.5
Fracture	Silky	Silky	Silky

The superiority of the drag and cope tests is manifest and is easily explained because, at the center of any steel casting, there is a lessening of the density of the steel owing to shrinkage.

From this study of the subject it is evident that if a locomotive steel cast frame of average cross-section is heated above the recalescence point and held there a sufficient length of time the frame has been completely annealed and relieved of all strains. In foundries where most of the locomotive frames are made this is the practice, and if adhered to strictly an excellent product is sure to be the result.

The Becquerel Memorial Lecture of the Chemical Society

Sir Oliver Lodge Reviews the Field Opened by the French Physicist

An extra meeting of the Chemical Society was held on Thursday, October 17th, when Sir Oliver Lodge, F.R.S., delivered a memorial lecture in honor of Antoine Henri Becquerel, late honorary and foreign member of the Chemical Society.

Sir Oliver Lodge referred to the changes that of recent years have come over physical science. Not many years back its progress appeared to be placid, along well-worn channels, and based upon the substantial knowledge of the past. To-day it is characterized by intense speculative activity on the one hand, and, on the other, by exceptional scepticism.

Discoveries are of two chief kinds: the discovery of law and the discovery of fact. The discovery of law often leads to the discovery of new facts, and the discovery of new facts to either the formulation of new laws or new modes of statement, or to the resuscitation of discarded ones. As examples of the discovery of law may be instanced Newton's gravitational theory of astronomy, Maxwell's electro-magnetic theory of light, the atomic theory of chemistry, and the conservation of energy. As examples of the discovery of fact may be quoted the prehistoric discovery of flame, the discovery of static electrification, of the electric current, of magneto-electricity, of the electron, and of spontaneous radio-activity.

Of the scientific discoveries made during the past fifty years, that of the Röntgen X-rays perhaps created the most widespread interest; but even more striking and revolutionary was Becquerel's discovery of the spontaneous radio-activity of matter, for the spontaneous splitting up of atoms and the consequent expulsion of constituent fragments was not provided for in any theory.

A discovery of essential novelty cannot be made by following up a train of prediction. It is often made during the process of following a clue, but the clue does not logically lead to it. A really new fact comes as a side issue—something unexpected and that might have been overlooked. The discovery which has been pointed to by theory is of great value, but it is usually the outcome of a long and fruitful period; whereas the discovery which comes as a surprise generally marks a fresh epoch, and opens a new chapter in science.

So with the discovery of spontaneous radio-activity. Becquerel was looking for the possible emission of Röntgen rays by a fluorescent substance. It was a reasonable thing to look for, and had it been found would have made an interesting extension of our knowledge; but, when critically examined, the kind of radiation turned out to be for the most part not Röntgen rays, but corpuscular, and to have nothing to do with fluorescence.

Becquerel set himself carefully to examine the kind of penetrating radiation which fluorescent substances exposed to light might be found to emit. Though not finding that for which he sought, he made a discovery of far greater importance.

After giving an account of the recent discoveries in radio-activity, the lecturer dwelt on the present trend of scientific thought; of the tendency to return to discarded hypotheses, such as spontaneous generation and the corpuscular theory of light. Our attitude among so many conflicting hypotheses should be to admit that any law applicable to concrete objects and established by induction on a basis of experience must be of the nature of a postulate; that we should hold some of the postulates as so well-established that arguments necessitating their overhauling should *ipso facto*, to that extent be discredited, and should not receive our encouragement unless supported by new facts. Our endeavors should be to harmonize new facts with the firmly established laws of physics until compelled to look for some higher generalization.

Reference was then made to some of the well-established laws, and to the attempts to construct living matter from artificially combined materials. Life demands energy for its manifestations, and radio-activity may be suggested as a possible source of such energy. It is known that atoms give off energy as they disintegrate; that organic compounds likewise disintegrate and evolve energy, finally becoming inorganic. A decaying heap of refuse represents a close chemical analogy to the physical activity of uranium—one is an affair of atoms, the other of molecules. This stock of energy running to waste seems eligible for guidance. Life has to control this spontaneous disintegration of protoplasmic cells, to regulate the activity of the ganglia in the brain, for instance, or to suspend the disintegration of organic material until some appointed time, and then to direct it along some determined channel. We have yet to discover how life achieves this control. Those who say that life cannot guide material processes unless it is itself a form of energy, and those holding that life cannot act at all unless energy is at its disposal, forget the spontaneous activity of complex organized molecules and the atomic disintegration manifested by radio-activity.

There is a great difference between matter potentially living and actually alive. In the physical universe our power is limited to the movement of matter; after that, all that happens is due to the properties of matter and its ethereal environment. If potentially living matter is ever artificially made by placing things in juxta position and bringing physical resources to bear upon the assemblage, then it may become alive. If this last step be taken, it will be because something beyond matter, something outside the region of physics and chemistry, has stepped in and utilized the material aggregate provided. Only in this sense did the lecturer consider that the artificial incarnation of life would be possible. Some day life may appear under observation, but it will not be manufactured, any more than radium or radio-activity has been manufactured.

Sir Oliver Lodge spoke of the tendency of present-day science to materialize the invisible, quoting, among other examples of this, the fact that plague, which in olden times was attributed to such mysterious causes as a conjunction of the planets, the iniquities of the Jews, etc., is now known to be due to a minute vegetable parasite living on the fleas of rats.—*Nature*.

Why Do Business Men Fail?

By W. C. Holman.

According to the report of Bradstreet's, 12,646 failures occurred in the United States during 1911, and of this number 3,414 were directly attributable to incompetence. The percentage due to the various causes is tabulated as follows:

Lack of capital	13.4
Incompetence	27.0
Specific conditions	16.9
Fraud	10.6
Inexperience	41.1
Competition	2.9
Neglect	2.2
Unwise credits	2.0
Failures of others	1.3
Extravagance	.9
Speculation	.7

—*Canadian Machinery.*

Plant Food in Relation to Soil Fertility*

The Problem of Restoring American Soil and Maintaining Prosperity

By Cyril G. Hopkins

RECENT publications from the Federal Bureau of Soils have strongly affirmed that there is no necessity of applying plant food in the restoration and maintenance of soil fertility. Two principal questions are raised: First, Does plant food applied increase crop yields in harmony with recognized soil deficiencies and crop requirements? Second, Will the rotation of crops maintain the productive power of the soil by avoiding injury from possible toxic excreta from plant roots? I shall try to present facts and data and exact quotations rather than my own opinions concerning these questions of such fundamental importance in relation to systems of permanent agriculture.

In 1804 DeSaussure, the French scientist, first gave the world a correct and almost complete statement concerning the sources of the food of plants, including not only the confirmation of Sénébier's discovery of the fixation of carbon in the formation of carbohydrates, but also the evidence of plant requirements for the essential mineral elements secured from the soil.

Sir Humphrey Davy and Baron von Leibig did much to popularize this information during the following half century; and they were followed by Lawes and Gilbert, whose extensive and long-continued investigations furnished the needed proof that the soil must furnish nitrogen as well as the mineral elements; and finally, only twenty-five years ago, Hellriegel discovered the symbiotic relationship between legumes and bacteria which gives access to the inexhaustible supply of atmospheric nitrogen for soil enrichment.

Briefly, it might be said that for nearly a century the world of science has accepted and taught, and the world of advanced agricultural methods has practised, the doctrine that soil fertility maintenance and soil enrichment require the restoration or addition of plant food, including particularly phosphorus and nitrogen, which are most likely to become deficient in normal soils, potassium where needed, and sometimes lime or limestone, which always supplies calcium, and magnesium as well if dolomitic limestone be used. Of the other five essential elements, carbon and oxygen are secured from the carbon dioxid of the air, hydrogen from water, and iron from the inexhaustible supply in the soil; while the sulphur brought to the soil in rain and otherwise from the atmospheric supply, resulting from combustion and decomposition of sulphur-bearing materials, supplemented by the soil's supply and by that returned in crop residues, appears to be sufficient to meet the plant requirements and the loss by leaching.

After nearly a century of the increasing agricultural practise of this doctrine on much of the farm land of Germany, France, Belgium, Holland, Denmark and the British Isles, those countries have approximately doubled their average acre-yields. The ten-year average yield of wheat in the United States is 14 bushels per acre, while that in Europe has gone up to 29 bushels in Germany, to 33 bushels in Great Britain, and to more than 40 bushels per acre in Denmark. The annual application of phosphorus even to the soils of Italy has already become greater than the phosphorus content of all the crops removed. The exportation of our highest grade phosphate rock from the United States to Europe now exceeds a million tons a year, carrying away from our own country twice as much phosphorus as is required for the annual wheat crops of all the States, and millions of acres of farm land in our own Eastern States have already been agriculturally abandoned, because of depleted fertility and reduced productive power; so that it is now impossible for our congressmen to enter the capital of the United States from any direction without passing abandoned farms.

Ultimate analysis has shown that the most common loam soil of southern Maryland,[1] almost adjoining the District of Columbia, contains only 160 pounds of phosphorus, 1,000 pounds of calcium and about 900 pounds of nitrogen in two million pounds of surface soil, corresponding approximately to an acre of land 6 2/3 inches deep. The clover crops harvested from the rich garden soil at Rothamsted in eight consecutive years removed more phosphorus and calcium from the soil than the total amounts contained in the plowed soil of this worn-out Maryland land, whose total nitrogen content is also less than would be required for seven such crops of corn as we harvest on good land in the central west, which, however, contains ten times as much of these plant foods as the depleted Maryland soil.

During the last ten years our population increased 21 per cent, the same as during the preceding decade, while the acreage of farm lands increased only 5 per cent, and the Federal Government reports all future possible increase in farm land at only 9 per cent of our present acreage.

Average crop yields for four ten-year periods are now reported by the United States Department of Agriculture. A comparison of two twenty-year averages shows increased acre-yields of 1 bushel for wheat and ½ bushel for rye, while the yield of corn has decreased 1½ bushels and the yield of potatoes has decreased 7 bushels per acre, by twenty-year averages. These crops represent our greatest sources of human food, even our supply of meat being largely dependent upon the corn crop. Less than twenty-year averages are not trustworthy for a consideration of any small increase or decrease in yield per acre. It should be noted that during the last forty years vast areas of virgin wheat land have been put under cultivation, including the Dakotas, which now produce more wheat than all the States east of the Mississippi, save only Indiana and Illinois.

A comparison of the last five years with the average of the five years ending with 1900 shows that our wheat exports decreased during the decade from 198 million to 116 million bushels, and that our corn exports decreased from 193 million to 57 million bushels.

Thus we have fed our increasing population not by increasing our acre-yields, but by a slight increase in the acreage of farm land, and by a large decrease in our exportation of food stuffs; and the fact must be plain that before another decade shall have passed we shall reach the practical limit of our relief in both of these directions.

Indeed, a most common subject already discussed in the press and investigated by national, State and city authorities during the last three or four years is the high cost of plain living.

With these facts and statistics before us, let us consider the actual results secured from field and laboratory investigations:

Where wheat has been grown every year since 1844 on Broadbalk Field at Rothamsted, England, the average yield for fifty-five years has been 12.9 bushels per acre on unfertilized land, 35.5 bushels where heavy annual applications of farm manure have been made, and 37.1 bushels per acre where slightly less plant food has been applied in commercial form.

Barley grown every year on Hoos Field at Rothamsted has produced, for the same fifty-five years, an average yield of 14.8 bushels on unfertilized land, 47.7 bushels with farm manure and 43.9 bushels where much less plant food was applied in commerical form.

Potatoes grown for twenty-six consecutive years, also on Hoos Field at Rothamsted, produced, on an average, 51 bushels per acre on unfertilized land, 178 bushels where farm manure was used (reinforced with acid phosphate during the first seven years), and 203 bushels where plant food was applied in commercial form. The first year of this investigation the unfertilized land produced 144 bushels, land receiving farm manure alone produced 159 bushels and land fertilized with commercial plant food produced 328 bushels per acre.

Director A. D. Hall, of the Rothamsted Experiment Station, makes the following statement on pages 95 and 96 of his book on "The Rothamsted Experiments:"

"On the plots receiving farmyard manure, and even on those receiving only a complete artificial manure, the crop was maintained in favorable seasons. No falling-off was observed which could be attributed to the land having becoming 'sick' through the continuous growth of the same crop, or through the accumulation of disease in the soil."

In commenting upon these same experiments, Milton Whitney, Chief of the United States Bureau of Soils, makes the following statement in Farmers' Bulletin No. 257, page 14:

"One of the most interesting instances going to show that toxic substances are formed and that what is poisonous to one crop is not necessarily poisonous or injurious to another is a series of experiments of Lawes and Gilbert —the growing of potatoes for about fifteen years on the same field. At the end of this period they got the soil into a condition in which it would not grow potatoes at all. The soil was exhausted, and under the older ideas, it was necessarily deficient in some plant food. It seems strange that, under our old ideas of soil fertility, if the soil became exhausted for potatoes, it should grow any other crop, because the usual analysis shows the same constituents present in all of our plants, not in the same proportion, but all are present and all necessary, so far as we know. This field was planted in barley, and on this experimental plot that had ceased to grow potatoes they got 75 bushels of barley."

If, now, we turn to the actual records of the Rothamsted experiments we find that the first crop of barley grown after twenty-six years of potatoes was 33.2 bushels per acre on unfertilized land, only 24.8 bushels where minerals alone had been used and the soil depleted of nitrogen by the potato crops, 67 bushels per acre where minerals and nitrogen had been used, and 72.4 bushels where farm manure had been applied for twenty-six years. We also find in strict harmony with Director Hall's statement, that the largest average yield of potatoes from the farm manure plots (3 and 4), either for one year or for five years, was secured after potatoes had been grown on the same land for more than fifteen years.

On permanent meadow land at Rothamsted, the average yield of hay for fifty years was 1¼ tons per acre on unfertilized land, and more than 4 tons per acre on land heavily fertilized with commercial plant food. During the last ten years of this fifty-year period the unfertilized land has produced an average yield of 1,863 pounds of hay, while the fertilized land has produced 8,490 pounds per acre.

On Barn Field at Rothamsted, mangels were grown for thirty years. The average yield per acre was 4¼ tons on unfertilized land, 19½ tons where farm manure had been applied, and 29 tons per acre where the farm manure had been reinforced with nitrogen and phosphorus in commercial form.

In 1902 the University of Illinois began a series of experiments on the common corn-belt prairie land in McLean County, on a field which had grown no wheat for thirty-two years. We first grew wheat in 1905. Four plots not receiving phosphorous produced, respectively, 28.8 bushels, 30.5 bushels, 33.2 bushels and 29.5 bushels of wheat per acre; while four other plots which differed from these only by the addition of phosphorus, at the rate of 25 pounds of that element in 200 pounds of steamed bone meal per acre per annum, produced 39.2 bushels, 50.9 bushels, 37.8 bushels and 51.9 bushels respectively, per acre. Six years later wheat was again grown on this land, when the four plots not receiving phosphorus produced, respectively, 22.5 bushels, 25.6 bushels, 21.7 bushels and 27.3 bushels per acre, and the other four plots, which differ from these in treatment only by the phosphorus applied during the ten years, produced 57.6 bushels, 60.2 bushels, 54.0 bushels and 60.4 bushels, respectively of wheat per acre, this being the second crop of wheat grown on this land in forty years.

This most common prairie land of the Illinois corn belt contains 600 pounds of phosphorus and 18,000 pounds of potassium per million of surface soil, while one million pounds of the subsoil contains 450 pounds of phosphorus and 27,000 pounds of potassium. This is the type of soil on which, as an average of four different tests each year under four different conditions of soil treatment, the addition of phosphorus produced an increase in yield per acre of 9.6 bushels of corn in 1902, of 17.8 bushels of corn in 1903, of 14.8 bushels of oats in 1904, of 14.4 bushels of wheat in 1905, of 1.46 tons of clover in 1906, of 18.8 bushels of corn in 1907, of 17.3 bushels of corn in 1908, of 15.2 bushels of oats in 1909, of 2.56 tons of clover in 1910 and an average increase of 33.8 bushels of wheat per acre in 1911.

As an average of four similar tests during the ten years, applications of potassium (costing the same as the phosphorus) increased the yield of corn by 3.1 bushels, decreased the yield of oats by 2.3 bushels, decreased the yield of clover by 70 pounds per acre and increased the yield of wheat by 0.1 bushel per acre, these being the general average results from four years of corn and from two years each of oats, clover and wheat.

If now we turn to the extensive peaty swamp soil of northern and north-central Illinois, we find by analysis that it contains in one million pounds of the surface soil 1,960 pounds of phosphorus and 2,930 pounds of potassium, or more than three times as much phosphorus and less than one sixth as much potassium as the common prairie. We also find that, as an average of triplicate tests each year, potassium increased the yield of corn per acre by 20.7 bushels in 1902, by 23.5 bushels in 1903, by 29.0 bushels in 1904 and by 36.8 bushels in 1905; while the addition of phosphorus produced a decrease of 0.

* Presented at the Symposium on Soils at the Washington meeting of the American Association for the Advancement of Science.

[1] See "Leonardtown Loam," Bureau of Soils Bulletin 54, and "Field Operations of the Bureau of Soils" in Reports for 1900 and 1901; or see pages 138 to 142 of "Soil Fertility and Permanent Agriculture," Ginn & Co., Boston.

bushel in 1902 and an increase of 0.9 bushel in 1903, of 3.9 bushels in 1904 and of 0.3 bushel in 1905.

As an average of the results from twenty plots of unfertilized land in the Pennsylvania rotation experiments with corn, oats, wheat and hay (clover and timothy mixed), the crop values in two consecutive twelve-year periods decreased by 26 per cent; while, as an average of the twenty-four years, the crop values were increased 62 per cent by farm manure and 65 per cent with commercial plant food, as compared with results on unfertilized land.

The records from the Agdell rotation field at Rothamsted show that as an average of the turnips, barley, clover (or beans) and wheat the yield decreased on unfertilized land by 42 per cent measured by the results from two consecutive thirty-two-year periods; and, if we span a sixty-year period, we find that the yield of turnips on unfertilized land was 10 tons per acre in 1848 and less than ½ ton in 1908; that the barley yielded 46.5 bushels in 1849 and only 10 bushels per acre in 1909; the clover produced 2.8 tons in 1850 and less than 1 ton per acre in 1910; while the wheat following clover produced 39.7 bushels in 1851 and 24.5 bushels in 1911.

The application of plant food (for the turnip crop only) in the same rotation over a period of sixty-four years increased the average yield of turnips from 1¼ tons to 17½ tons per acre, increased the yield of the barley following from 24.4 to 38.5 bushels, then increased the average yield of legumes from 1,945 pounds to 4,413, and increased the yield of wheat after legumes from 25 to 34.8 bushels, as compared with the unfertilized land.

If, again, we span the sixty years, we find that on the fertilized land the yield of turnips was 12½ tons in 1848 and 17½ tons in 1908; that barley produced 35.9 bushels in 1849 and 33.4 bushels in 1909; that clover produced 3½ tons in 1850 and 4½ tons in 1910; while wheat yielded 30.3 bushels in 1851 and 38 bushels per acre in 1911.

Thus, the records show that during the last four years, following a sixty-year period, the plant food applied has increased the yield of wheat by 55 per cent, increased the barley by 234 per cent and the clover by 340 per cent; while the yield of turnips on the fertilized land was 49 times as great as on the unfertilized land.

With these facts in mind we may well consider the following from Whitney in Farmers' Bulletin 257:

"Apparently, these small amounts of fertilizers we add to the soil have their effect upon these toxic substances and render the soil sweet and more healthful for growing plants. We believe it is through this means that our fertilizers act rather than by supplying food to the plant.

"There is another way in which the fertility of the soil can be maintained, viz., by arranging a system of rotation and growing each year a crop that is not injured by the excreta of the preceding crop; then when the time comes around for the first crop to be planted again the soil has had ample time to dispose of the sewerage resulting from the growth of the plant two or three years before. . . . Barley will follow potatoes in the Rothamsted experiments after the potatoes have grown so long that the soil will not produce potatoes. The barley grows unaffected by the excreta of the potatoes, another crop follows the barley, and the soil is then in condition to grow potatoes again.

"In other experiments of Lawes and Gilbert they have maintained for fifty years a yield of about 30 bushels of wheat continuously on the same soil where a complete fertilizer has been used. They have seen their yield go down where wheat followed wheat without fertilizer for fifty years in succession from 30 bushels to 12 bushels, which is what they are now getting anually from their unfertilized wheat plot. With a rotation of crops without fertilizers they have also maintained their yield for fifty years at 30 bushels, so that the effect of rotation has in such case been identical with that of fertilization."

If we turn to the Rothamsted data, we find that the first recorded yield of wheat on the unfertilized plot on Broadbalk Field was not 30 bushels, but only 15 bushels; that the average of the first eight years was 17.4 bushels; that the best fertilized plot on the same field has averaged not 30 bushels, but 37.1 bushels for fifty-five years; that, as stated above, the wheat grown in rotation, following a leguminous crop, has averaged not 30 bushels, but 25 bushels on unfertilized land, and 34.8 bushels where fertilizers are applied for turnips three years before.

The following pertinent quotations are from Whitney and Cameron in Bureau of Soils Bulletin 22:

"In England and Scotland it is customary to make an allowance to tenants giving up their farms for the unused fertilizers applied in previous seasons. The basis of this is usually taken at 30 to 50 per cent for the first year, and at 10 to 20 per cent for the second year after application; but, in the experience of this bureau there is no such apparent continuous effect of fertilizers on the chemical constitution of the soil. (Page 59.)

"It appears further that practically all soils contain sufficient plant food for good crop yield; that this supply will be indefinitely maintained." (Page 64.)

In Bureau of Soils Bulletin 55, by Whitney, entitled "Soils of the United States," issued in 1909, we find under the heading "Permanency of Soil Fertility as a National Asset" the following summarized statements:

"The soil is the one indestructible, immutable asset that the nation possesses. It is the one resource that can not be exhausted; that can not be used up. (Page 66.)

"From the modern conception of the nature and purpose of the soil it is evident that it can not wear out, that so far as the mineral food is concerned it will continue automatically to supply adequate quantities of the mineral plant food for crops. (Page 79.)

"As a national asset the soil is safe as a means of feeding mankind for untold ages to come." (Page 80).

As stated in the beginning, I have not planned to discuss the subject of plant food in relation to soil fertility; but I felt it a duty as well as an honor to be permitted to accept a place on your programme; and I have placed before you some most important and trustworthy data bearing upon the question. I have presented some statistics for consideration in connection with the gravest problem which now confronts America, namely, the problem of restoring American soil and of maintaining American prosperity. I have quoted accurately and fairly from the teachings of Whitney and Cameron; and I also submit for your information the following quotation from Director A. D. Hall, of Rothamsted:

"I cannot agree with Prof. Whitney's reading of the results on the Agdell field in the least. The figures he quotes for wheat are hardly justifiable as approximations, and are in spirit contrary to the general tenor of the particular experiment. . . . In my opinion the results on the Agdell rotation field are directly contrary to Prof. Whitney's idea that rotation can do the work of fertilizers. (From Report of the Committee of Seven, appointed by the Association of Official Agricultural Chemists 'to consider in detail the questions raised,' published in full in Circular 123 of the University of Illinois Agricultural Experiment Station.)"

All long-continued investigations and, likewise, all practical agricultural experience show that great reduction in crop yields ultimately occurs unless plant food is restored to the soil; and, as a rule, the chemical composition of normal soil is an exceedingly valuable guide in determining the kinds of material which should be supplied in practical systems of soil enrichment and preservation.

Fire Hazards in Rubber Manufacture*

By L. Alexander Mack

The greatest hazard in the manufacture of rubber products is not the rubber itself but its solvents. "Rubber cement," as it is commonly called, is composed of pure rubber, cut fine and softened in carbon dioxide, after which this mixture is dissolved in benzene, making a powerful adhesive. The dangers of volatile fumes of benzene are well known to every underwriter, and the danger from careless use of rubber cement cannot be too strongly emphasized. The inspector should devote particular attention to this material, first as to its storage, and, secondly, as to its actual use. It is worth noting, however, that once the cement has been applied and becomes dry, the danger point appears to have been passed.

STORAGE OF RUBBER CEMENT.

Manufacturers realize that with a costly product like rubber cement it is important that every gallon purchased should be used. This result cannot be obtained when the wooden barrel which has served for its transportation is afterward used for storage. Such a barrel is more or less porous, and so in the best plants the cement is at once transferred to metal tanks, buried underground at least thirty feet from any building. This is the only safe and approved method of storage of rubber cement. The inspector should satisfy himself that only a day's supply of cement is kept in the factory at one time, and this must be kept in self-closing metal cans. It seems almost needless to say that smoking should be prohibited within any portion of a plant where such material as rubber cement is used in almost every department.

STATIC ELECTRICITY.

Next to the hazard of rubber cement is the danger from static electricity. Instances are of frequent occurrence, where in moving a sheet of rubber-lined cotton duck or belting across a table top enough static electricity is developed to generate a good sized spark. This is extremely dangerous if there is any rubber cement near by. The best safeguard against this hazard is to have all tables in this department "grounded" —a simple expedient for every manufacturer.

BUFFING.

Some attention should be given to the department where buffing is carried on. The fine dust, here given off, though composed partly of rubber, has an admixture of lint fro mthe buffing wheels themselves. This finely divided material, if allowed to accumulate, would make an excellent subject for spontaneous combustion, especially if left where any grease or oil could drop on it. Complete blower systems should be installed to carry the dust direct to the boiler room, where it should be destroyed as soon as practicable. There is very little danger of the buffers developing enough heat to set fire to any fumes of benzene in this department.

STORAGE AND WASHING.

The storage of crude rubber under suitable conditions does not present any undesirable features from the underwriter's viewpoint. Nor does the process of washing, for, in spite of the frequent presence of foreign substances, water is so necessary an adjunct to this process as to make fire an impossibility at this stage of the work.

The rubber manufacturer thus need not fear the risk of fire through the storage of crude rubber or the processes incidental to purification.

CHEMICAL ROOM.

The chemical room should be carefully inspected to make sure that all chemicals are stored in standard self-closing bins of lock-jointed tin. The best mills store their chemicals in a separate building from which the boxes containing mixed chemicals and raw rubber stock are conveyed by a belt to the mixing machines. Lampblack is a decidedly dangerous substance, composed almost entirely of carbon. If it becomes damp it will heat up sufficiently to char its paper wrappings, or the paper linings of barrels in which it has been shipped, and if left long enough will eventually set fire to the barrel itself. Barium sulphate is a rapidly oxidizing metallic substance which is a frequent source of trouble if allowed to become damp; carbon disulphide is a liquid similar to benzene in its volatile and explosive qualities. There is danger also from unslaked lime becoming slaked and setting fire to things about it. Sulphur is not bad, and there is no danger from whiting, paraffin or litharge.

MIXING AND CALENDERING.

In the mixing process the underwriter will find little or no special hazard, as a high temperature would spoil the rubber. The temperature of the mixing rollers is maintained at about 176 deg. Fahr., and steam heat is now almost universally employed.

VULCANIZING.

The fire hazard from the vulcanizers cannot be said to amount to anything more than the usual steam pipe hazard, steam being the medium now employed in vulcanizing in practically all factories. With the boiler house properly isolated and the vulcanizers set on metal, and with all surrounding woodwork protected with metal sheathing, the hazards of the vulcanizer can be reduced to a minimum.

RECLAIMING HAZARDS.

The hazards of the reclaiming house are chiefly those of the storage of chemicals. Sulphuric acid, nitric acid and caustic soda are the chemicals principally used. All are dangerous unless kept in approved receptacles, preferably in a detached building. The machinery and arrangement of the reclaiming plant present no more serious hazard than that the floors must of necessity be pierced in numerous places to facilitate the handling of the reclaimed material, thus making a total loss on this structure a high probability if fire once gets a start.

MISCELLANEOUS.

As before indicated, the hazard of oily waste and lint is to be looked for in the department where jackets are woven for hose. Self-closing metal cans should be provided for waste in this department. Large plants frequently run their own printing establishments. Benzene is the dangerous substance here, and should be kept in patent safety cans and only a day's allowance kept in the shop at one time.

OTHER RUBBER INDUSTRIES.

While this article will not deal with the hazards to be found in factories making rubber clothing, boots and shoes, tires and druggists' sundries, it will be well to note that the hazard in the clothing industry is chiefly in the spreading of the daub, which is virtually a rubber cement mixture. Static electricity is the dangerous feature here. In the boot and shoe industry the lacquering room seems to be the source of trouble. Here the lacquer, composed of highly inflammable materials, is "slathered" over the boot or shoe by hand, and the article is at once put on a rack and taken into the drying room, where a high temperature prevails. Trouble may frequently develop here.

FIRE PROTECTION.

A full equipment of fire pails, extinguishers, standpipe and hose, and, above all, a thorough sprinkler equipment, will do much toward making rubber works profitable to the underwriters. Good housekeeping is, of course, an essential to every well organized factory, and should be insisted upon by the inspector.

* Reproduced from *The Weekly Underwriter*.

View Facing West on North Side of Tracks, Showing Tender Body, Girder "A" and Engine Cab in a Lot, and Parlor Cars Turned Over on Track No. 5.

Looking West on Track No. 3 and a Portion of the Crossover No. 3 to No. 5 from 25 Feet Back of the Switch Heel of the Same Crossover.

The Westport Disaster

Report of the Connecticut Public Utilities Commission

[*In view of its importance to the public and the railroads we publish here in full the report of the chief engineer and inspector of his examination into the causes of and circumstances connected with the accident occurring at Westport on the 3rd day of October, 1912.*—EDITOR.]

TO THE HONORABLE PUBLIC UTILITIES COMMISSION:

Gentlemen: The following is a report of my investigation of the above accident:

The investigation of this accident, particularly as to the examination of witnesses, was made in conjunction with the Interstate Commerce Commission, a member of your Commission and myself being present at the hearing held by the Interstate Commerce Commission in New York, on October 8th and 9th, 1912.

At 4:44 o'clock P. M. on Thursday, October 3rd, 1912, in daylight and clear weather, the second section of the New York, New Haven & Hartford Railroad Company's westbound passenger express train, No. 53, consisting of engine No. 1,014, Pacific type, one mail car, one baggage car, four parlor cars and four coaches, was derailed and wrecked when crossing from track No. 1 to track No. 3, eight hundred feet west of the westbound passenger station at Westport.

Judging from the evidence of several who witnessed the accident and from well defined marks on the rails, ties and interlocking apparatus, the engine left the main track near the frog of switch leading from track No.3 to track No. 5, and stopped right side downward on track No. 5, about four hundred and fifty feet from the point of derailment.

An explosion occurred, probably caused by the boiler being punctured when it struck the steel bridge over Riverside Avenue. The concussion was sufficient to break windows one hundred feet away.

In crossing the bridge over Riverside Avenue the north girder was torn away from the bridge seats and floor system and deposited on top of the engine tank, on the right of way north of the tracks; and the next girder between tracks No. 3 and No. 5 was crushed and crowded down into the street below.

The mail car, which was coupled to the engine, was thrown over on its side and stopped just east of the engine, while the baggage car passed by the engine and landed right side up, minus its wheels, on track No. 1. Parlor car. No. 2145 (the third car in the train) was

Looking West Over Tracks No. 1 and No. 3, Standing Between Tracks No. 1 and No. 2, About 90 feet East of Signals Showing the Home and Dwarf Signals.

jammed against the engine and evidently was ignited from the fire box of the engine. This parlor car and the two next behind it, No. 2234 and No. 2249, were wrecked and totally destroyed by fire. The remaining parlor car, No. 2217 and the four coaches in the rear, were but slightly damaged. There was no evidence that the gas tanks under the parlor cars exploded and were responsible for he burning of the cars.

The estimated damage to equipment, track and bridge, is placed at $70,485, but the saddest part of the whole affair was the death of seven persons, and the injury to thirty-six others. Four of those killed were women who occupied parlor car No. 2145, and were probably burned to death.

The engineer and fireman were killed, and one mail clerk was so seriously injured that he died while being carried to the hospital.

The railroad traffic between New York and New Haven is handled over a four-track division. The southerly tracks, which are designed to accommodate eastbound trains, are numbered "two" and "four" and the northerly tracks used for westbound trains, are numbered "one" and "three."

To operate the road to the best advantage it often becomes necessary to divert trains from one track to another; by so doing, express trains are permitted to "run around" slower ones while both are under headway. For such movements, crossover switches are located at interlocking signal towers. These switches are handled by operators in the towers and are so interlocked that it is impossible to change them until corresponding signals are set for the guidance of approaching trains.

Three types of crossovers are found on this division, viz., No. 8's, No. 10's and No. 15's. The numbers refer to the size of frogs used. The curvature of the track associated with a No. 8 frog is much sharper than with either a No. 10 or a No. 15; in other words, the curvature decreases as the frog number increases.

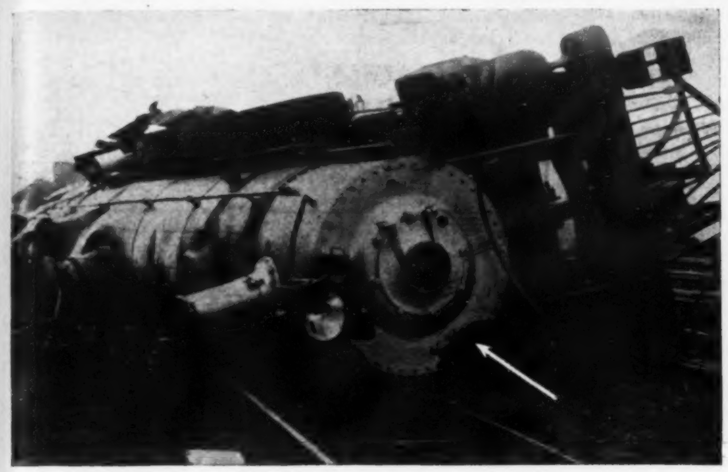
The tracks approaching Westport from the east are straight for some distance, but there is a slight change in the alignment 640 feet west of the station, the track curving to the left and continuing on a one degree and six minute curve for about 900 feet. The easterly half of the crossover from track No. 3 to track No. 1 is located in straight track, while the westerly half is on the inside of the curve.

On account of heavy westbound travel, train No. 53 was run in two sections. The first section made up at Springfield and composed of coaches, left Bridgeport, its last stopping place, at 4:18 P. M. on time. This train is scheduled to run on track No. 3 from New Haven to Stamford and on track No. 1 from Stamford to Woodlawn, but because a construction train occupied track No. 3 near Westport, first No. 53 was diverted from its regular route at Bridgeport and run on track No. 1 to Westport, where it was crossed back again to track No. 3 and continued westward to its New York terminal.

The movement of first No. 53 from tracks No. 1 to No. 3 at Westport, was made according to rule, and in obedience to signals.

After the first section passed Westport, the tower operator, M. A. Coyle, restored his signals to their normal position and gave an "unlock" to the first towerman east of him located at Green's Farms. This permitted clear signals to be given second No. 53 at Green's Farms. The crossover switches on tracks No. 1 and No. 3 were not changed after the passage of the first section and when second No. 53 was announced from Green's

View West from West End of the Second Story of Signal Tower.



Note Mark of Middle Girder on Front End of Engine.

Note Mark of Right-hand Girder Where Boiler Was Punctured.

Farms, Operator Coyle cleared the westbound drawbridge signal for track No. 1 and set the dwarf signal for the crossover, keeping the distant signal at caution, and the home signal in stop position. Instead of bringing the train under control, because of the distant signal being at caution, the engineer continued to use steam and passed on over the drawbridge and by the station at an estimated speed of between forty and fifty miles per hour. There was apparently no effort made to check the speed until the engine was near the crossover, when an emergency application of the air was made, but too late to materially lessen the speed, and the engine passed through the crossover and the wreck occurred, as described.

The first one to witness the unusual action of the train was Bridge Tender Allen, who was on the drawbridge, five hundred feet east of the station. The tower operator also saw the impending danger and tried to signal the fireman, who, he said, was sitting on his seat looking straight ahead, as he passed the tower.

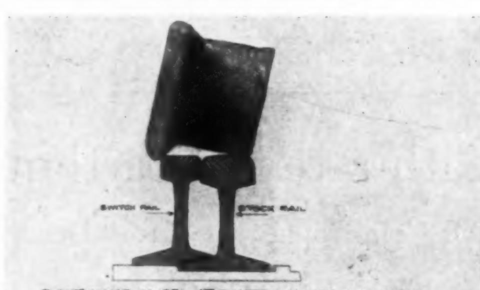
Work Train Conductor Grove Reynolds made a frantic effort to attract the attention of the engineer and fireman from where he stood, on the south side of the tracks between the tower and the station, while Section Foreman Gordon, who was working on track No. 1, a few feet west of the crossover, observed the train coming too fast to take the crossover safely, and swung his hat across the track as a signal for the engineer to stop. All of these warnings were apparently unheeded until it was too late to prevent the accident.

The rails, switches and frogs over which the train passed, after leaving track No. 1, must have been subjected to a very severe strain, but the only indication visible after the wreck, was a slight spreading of the gage, amounting to one inch in the widest place, at the joint midway between the westerly frog and switch of the crossover.

An examination made very soon after the accident failed to disclose any imperfections in signals, interlocking, or track, which could have caused the derailment, and all evidence goes to prove that the engine and other train equipment was in perfect order. It is, therefore, apparent that the accident was due to the failure of the

VIEW OF RIGHT HAND WHEEL WITH AXLE LEVEL; THE FLANGE OF WHEEL CROWDING THE RAIL.

RIGHT HAND WHEEL ON RAIL WHEN LEFT HAND WHEEL WAS RAISED 12 INCHES ABOVE RAIL.



RIGHT HAND WHEEL AT SWITCH WHERE STOCK RAIL AND SWITCH RAIL LIE NEXT TO EACH OTHER WITH LEFT HAND WHEEL RAISED 12 INCHES ABOVE RAIL.

engineer to obey the signals which should have governed the movement of his train when approaching Westport.

The absence of any unusual wheel marks on the rails east of the west switch of the crossover from track No. 1 to track No. 3, shows conclusively that the engine and tender passed through the crossover and was still upon the track when they reached the point of the facing switch leading from track No. 3 to the freight yard, and the character of marks west of this crossover prove that the tender was careening more than the engine, due to its centrifugal force and shifting load of coal and water, and that the left hand wheels of the forward tender trucks were not touching the rails, while the right hand flanges were pressing hard against the north rail.

This condition existed while they were going from the west end of the crossover to where the main rail meets this facing switch.

At this point, the width of the rail heads combined, gave a wider surface for the wheel treads, and the bearing which came on the outer part of the tread raised the inner or flanged part of the wheel and allowed it to cross the top of both the switch and stock rails; here the forward tender trucks were derailed and dropped onto the ties forty-four feet beyond. The five-foot draw bar connecting the engine to the tender, made it possible for the engine to keep on the main track until it reached the frog, where it lost its equilibrium, owing to the direct action of the derailed tender and aided by the centrifugal force of the engine itself.

Judging from the position in which the engine and tender were found after the accident, and from marks they bore and the condition of the tracks and bridge over which they passed, I believe that the engine was over on its right side with its head end on track No. 3, and the rear end with the tender, on track No. 5, as it crossed the bridge, at which point the tank was wrenched from the tender frame and hurled seventy-five feet away to the right of the tracks, surmounted by the north girder of the bridge which the engine sheared off in crossing the bridge.

The fact that the engine passed through and beyond the crossover at such high speed, is remarkable, and I feel sure that, had it encountered curves not exceeding four

Looking West on Track No. 1, 20 feet Ahead of Switch on Crossover, No. 1 to No. 3 Tracks.

Looking West on Track No. 3, 30 feet Back of Switch Heel on Crossover, No. 1 to No. 3 Tracks.

degrees, the train would have been unharmed in making the crossing. By using No. 15 frogs, the curvature of the switch leads on the inside of the one degree six minute curve would not exceed four degrees, but I would suggest that a longer crossover than a No. 15 be installed in place of the present one, which is a No. 10. Room for such a crossover is available between the present easterly switch point and the bridge over Riverside Avenue, the only obstacle being the facing switch leading to track No. 5 (where the derailment occurred) which should be removed in any event, and replaced by a trailing switch at the west end of track No. 5.

To insure safe operation and safeguard against accidents which might occur as a result of trains taking crossovers at excessive speed, I would suggest that *all* crossovers between parallel main tracks used for trains going in the same direction, and through which trains are detoured, be constructed with No. 20 frogs; and at points where conditions will not allow crossovers of such length, pending the installation of an approved automatic train control device, that signals be held at stop positions and switches kept set for straight movement until the approaching trains have come to a full stop.

PUBLIC UTILITIES COMMISSION ORDER AND RECORD WESTPORT WRECK.

The foregoing report, in so far as it states the circumstances and conclusions as to the causes of the accident, is approved and made a part of the Commission's "record of the causes, facts, and circumstances of" said accident.

It is apparent from the investigation of this case that the primary cause of the accident was the failure of the engineer to observe and follow the rules of the company, which, if complied with, would have prevented the wreck.

This Commission can pass no order which will overcome human frailty in so far as the individual is concerned. The history of railroad operation proves that human agency, under the most favorable conditions and exercised by the most trusted and competent employees, is liable to err, and it is the duty of the railroad company to adopt such improved mechanical devices and construction as will tend to prevent the disastrous results of uncontrollable human frailty.

The operation of a four-track railroad necessarily requires the maintenance of crossovers for detouring trains. The crossover where this accident occurred was a No. 10. It appears from the physical conditions, observed immediately after the accident, that the engine took the crossover from track No. 1 to track No. 3, remaining on the rails to a point beyond the switch on track No. 3, and that the tender was the first to leave the rails at the point of the facing switch leading from track No. 3 to track No. 5, strongly indicating that the facing point switch, inexcusably located, was an important factor (in connection with the high speed over the short No. 10 crossover) in causing the derailment.

Following the wreck of the Federal Express at Bridgeport, July 11th, 1911 (and before this Commission came into existence), Mr. H. W. Belnap, Chief Inspector of Safety Appliances for the Interstate Commerce Commission, in his report on said wreck, made recommendations which, if followed out, would undoubtedly have prevented the Westport wreck.

From the investigations made and report furnished by the Chief Engineer and Inspector of this Commission upon the length of the crossover at Westport, and from a knowledge of the fact that on the longer crossovers in use on the Pennsylvania Railroad, high speed trains are daily being operated in safety, this Commission is clearly of opinion that this accident would have been averted by the use of a No. 20 crossover.

It is also the opinion of this Commission, based on information acquired by consulting railroad civil engineers of high standing, that No. 20 crossovers are safe for high speed, and in view of the recommendations made in the report of the chief engineer and inspector of this Commission and the seriousness of said accident, this Commission, after full hearing had, at which the railroad company was represented, deem it equitable and in the interest of public safety and as a possible means of preventing similar accidents, to pass the following order:

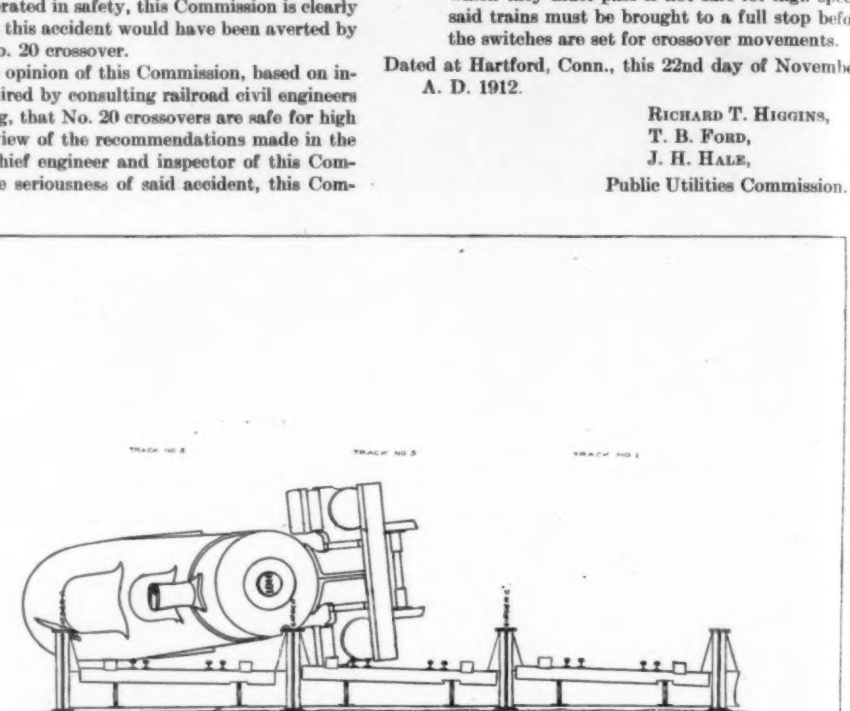
It is therefore ordered:

(1) That the New York, New Haven & Hartford Railroad Company be and it hereby is directed, forthwith, to remove said facing point switch leading from track No. 3 to track No. 5.

(2) When high speed trains are to be diverted from one track to another and the crossover through which they must pass is not safe for high speed, said trains must be brought to a full stop before the switches are set for crossover movements.

Dated at Hartford, Conn., this 22nd day of November, A. D. 1912.

Richard T. Higgins,
T. B. Ford,
J. H. Hale,
Public Utilities Commission.



SECTION OF RIVERSIDE AVE. BRIDGE – WESTPORT CONN
LOOKING EAST SHOWING TRACKS NO 1, 3 AND 5 WITH AN OUTLINE OF ENGINE NO 1014 IN POSITION IT WAS SUPPOSED TO HAVE BEEN IN WHEN IT WENT OVER THIS BRIDGE
WRECK OF TRAIN NO 53 – OCTOBER 3 1912 AT WESTPORT CONN.
SCALE

The Death-rate of Earthquakes*

Of All Catastrophes the Most Deadly

By Charles Davison, Sc.D., F.G.S.

The destruction of Messina at the close of 1908 has made us familiar with the immense loss of life that may be accomplished within a few seconds by a great earthquake. The total number of deaths is still unknown; probably it will never be revealed but it cannot fall far short of 100,000. Seldom has this number been exceeded, though it has often been approached in other lands as well as in Italy. Taking the latter country first, we may recall the long series of earthquakes in 1783, when more than 30,000 lives were lost; and the Sicilian earthquake of 1693, when the number rose to more than 58,000 according to Dr. Baratta and to 93,000 according to Prof. Mercalli. Smaller but still considerable figures were attained in other earthquakes, for instance, 2,313 in the Ischian earthquake of 1883, 6,240 in the Norcian earthquake of 1703, 12,291 in the Neapolitan earthquake of 1857 and 15,000 in the Sicilian earthquake of 1169.

The Japanese records tell the same tale. In 1891, 7,273 lives were lost during the great earthquake in the provinces of Mino and Owari. Five years later, 27,000 persons were drowned at Kamaishi and along the neighboring coast by the sea-wave following an earthquake. To the Japanese, this wave was more costly in life than the whole war with China in 1894. Again, 30,000 persons were killed by the Kamakura earthquake of 1293 and the same number in Yechigo in 1828. But even these figures were surpassed in 1703, when the death-roll is said to have risen to 200,000, half of this number being in the district of Awa alone. In other countries, to give only a few more instances, we find that 50,000 were destroyed by the Lisbon earthquake of 1755, 40,000 in northern Persia in the same year, 60,000 in Cilicia in 1268, 100,000 in Pekin in 1731, 180,000 in India in 893, more than 80 per cent of this number having been buried in the ruins of one city, while 300,000 are said to have perished in the Indian earthquake of 1737. "As yet," wrote Humboldt in 1844, "there is no manifestation of force known to us, including even the murderous inventions of our own race, by which a greater number of people have been killed in the short space of a few minutes."

On the other hand, in some great earthquakes the loss of life has been surprisingly small. At Charleston in 1886, only twenty-seven were killed, though fifty-six more died afterwards from cold and exposure. At San Francisco, twenty years later, the earthquake was directly responsible for no more than 390 deaths; and the total number of lives lost at Kingston in 1907 is estimated at about 1,000.

In considering such statistics it is evident that the figures furnish no real test of the destructive violence of an earthquake. Some of the greatest shocks for many years past are those which have occurred in the sparsely inhabited regions of central Asia. The disastrous character of the Messina earthquake was chiefly due to the presence of a large and ill-built town near to its origin. The heavy death-rolls of earthquakes in India and China are to be attributed to the dense population of those countries. Consequently, instead of the death-roll, a more accurate measure would be the death-rate or the proportion deaths bear to the whole population. For instance, in Charleston during the earthquake of 1886 and more recently in San Francisco, the death-rate was considerably less than 1 per cent. In the Ischian earthquake of 1881, it amounted to 2¼ per cent at Casamicciola. In the Andalusian earthquake of 1884, the highest death-rate at any place was 9 per cent and in the Riviera earthquake of 1887 not more than 14 per cent. Though attracting great attention from their occurrence in well-known districts, these earthquakes belong to a group characterized by a comparatively small loss of life.

In contrast with the above figures, many of the Italian earthquakes are characterized by an unusually high death-rate. In the Ischian earthquake of 1883, the death-rate at Casamicciola was 41 per cent; in the Sicilian earthquake of 1693, it rose to 50 per cent at Ragusa and to 67 per cent at Catania; in the Neapolitan earthquake of 1857, it was 50 per cent at Saponara and 71 per cent at Montemurro; in the first great Calabrian earthquake of 1783, 59 per cent at Bagnara and 77 per cent at Terranova; while in the Norcian earthquake of 1703, the highest death-rate at any place was 81 per cent at Avendita. The corresponding figures for the Messina earthquake are not yet accurately known; at Canitello the death-rate was 44 per cent but in the lower part of Messina itself and Reggio di Calabria the rates may well exceed any of those given above.

Among the conditions which determine whether the death-rate due to an earthquake shall be high or low may be mentioned the time of occurrence, the suddenness with which the shock begins and the rapid succession of strong after-shocks. These are all properties of the earthquake and beyond our control. There are also others of no less consequence, which are governed more or less by our own actions, such as the proximity of towns to well-known seismic centers, the nature of the site selected—whether on sloping or level ground, on a rocky or loose foundation—and the nature of the buildings. I propose to consider these conditions in detail, as it is only from a knowl-

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ge of such conditions that we can expect to discover ans of mitigating, when we cannot altogether prevent, e disastrous effects of great earthquakes.

The time of occurrence is one of the most important tors. An earthquake which occurs at night is nearly ways more disastrous than one in the daytime. Not ly are people gathered indoors but, if asleep, they are able to take advantage of the brief warning that is metimes given by the preliminary sound or tremor. mong earthquakes with a high death-rate may be menned the Messina earthquake of 1908, which occurred about 5:20 A. M., the Ischian earthquake of 1883 at 25 P. M., the Neapolitan earthquake of 1857 at 10:15 M., the Kangra and Dharmsala earthquake of 1905 ortly after 6 A. M. and the great Indian earthquake of 737 at night. Among those with a low death-rate are e Assam earthquake of 1897, which occurred at 5:15 M., the Ischian earthquake of 1881 at 1:5 P. M., the ingston earthquake of 1907 at 3:30 P. M., the Port oyal earthquake of 1692 and the first Calabrian earthake of 1783 which happened shortly before and after on. But even the daytime loses its advantage when, ing to religious celebrations, many people are congated within doors. The Riviera earthquake of 1887, r instance, took place on an Ash Wednesday morning at enty minutes past six. After a night spent in amusent, many persons had lain down and were sleeping avily; others had risen early and were gathered tother in churches. The Caraccas earthquake of 1812 cured at 4:7 P. M. on Ascension Day. "The procession the day," says Humboldt, "had not yet begun to pass ough the streets but the crowd was so great within e churches that nearly three or four thousand persons re crushed by the falling of the roofs."

The suddenness of onset of the shock is a second factor considerable importance. Almost invariably the ock is preceded by a deep rumbling sound accomnied by a faint tremor which may last five or more secds before the vibrations attain a destructive strength; e same sound precedes both weak and strong shocks d at first affords no certain warning of the disaster but earthquake countries it is one that is always heeded. f it had happened in the middle of the night," wrote arwin of the Concepcion earthquake of 1835, "the eater number of the inhabitants . . . must have rished, instead of less than a hundred; as it was, the variable practice of running out of doors at the first embling of the ground alone saved them. In Concepon each house or row of houses stood by itself, a heap or e of ruins." To the same cause may be attributed the all loss of life in such earthquakes as those which stroyed Cumana in 1797 and Port Royal in 1692.

In many earthquakes, however, the warning given by e earthquake sound is too brief to be of service. This s the case, even with those who were awake, at Dharmla in 1905 and at Messina in 1908. In the Ischian rthquake of 1883 sound and preliminary tremor were th absent within the central district. So suddenly d with such intense violence did the shock begin that rvivors at Casamicciola found themselves beneath the ins of their houses before they realized that an earthake had occurred.

The death-rate of an earthquake is often increased by e rapid succession of strong after-shocks. In the cenl district every great earthquake is followed by almost essant tremors among which stronger shocks are interrsed. The Riviera earthquake of 1887 occurred at out 6:20 A. M. At 6:29 there followed a second shock d at 8:51 a third of intermediate strength. To these o shocks are attributed one quarter of the total amount damage and also the small number of wounded, many those who lay buried in the ruins having been killed the subsequent overthrow of the shattered walls. In is earthquake the number of persons wounded was only per cent of the number killed. The Neapolitan earthake of 1857 was succeeded after about an hour by other strong shock and the number of wounded was ly 14 per cent of the number killed. In the Andalusian rthquake of 1884 and the Japanese earthquake of 1891, the contrary, the number of wounded was more than uble that of the number killed.

Of the remaining conditions, the harmful effects of ich we can to a certain extent restrain, the most imrtant is the proximity of towns to well-known seismic nters. The unstable regions of the earth have been termined on a large scale by M. de Montessus de Bale and Prof. J. Milne, the map constructed by the forr being based on all recorded shocks and that of the tter on world-shaking earthquakes. The dangerous nes of certain countries, such as Italy and Japan, have o been carefully delineated. In Europe the large wns are far removed as a rule from earthquake centers. ose which have suffered most are Lisbon, Catania and essina, in addition to a number of small towns in the uth-east of Spain, in Ischia, Calabria, the Balkan ningula, the Ionian Islands, Crete and several islands the Grecian archipelago. Other countries are less rtunate. Off the west coast of South America and ecially from the tenth to the fortieth degree of south latitude, the steeply shelving ocean-bed marks the site of one of the most unstable portions of the globe. Nearly all the larger towns on the coast—Callao, Lima, Arequipa, Iquique, Copiapo, Coquimbo, Valparaiso, Concepcion and Valdivia—have been destroyed at some time or other, most of them more than once, several having suffered from the rush of the great sea-waves as well as from the force of the shock. The shores of the Pacific Ocean, indeed, are specially subject to seismic disturbances throughout a great part of their extent. Of the 675 "world-shaking" earthquakes which have been studied by Prof. Milne during the eleven years 1899-1909, three fifths have originated in the five zones which border that ocean, the greater number being submarine. Five other zones are entirely oceanic but these and a sixth zone containing the West Indian Islands include only one fifth of the total number of earthquakes, the remaining fifth originating in a great terrestrial zone extending from Italy eastwards to the Himalayas.

The most important feature of these seismic zones from our present point of view is that earthquakes shake particular portions time after time, although they occur in other places in the intervals. As on the west coast of South America, the same towns are repeatedly destroyed, either entirely or in part. For instance, Reggio, Monteleone and Catanzaro have been rebuilt several times; also Antioch, Tripolis and Damascus in Asia Minor; Erivan, Tabriz and Meshed in Persia; and Cumana and Caraccas in Venezuela. Volcanic earthquakes, however, such as those of Ischia, may be concentrated for successive centuries within the same small areas.

To a very considerable extent, the destructiveness of a shock depends on the nature of the ground, so that within the area of a single town there may be many variations in the amount of damage to the buildings. In the city of Tokyo, there are two well-defined districts, one consisting of hard high ground, the other of low soft ground, the intensity of the earthquakes being much less on the former than on the latter. In towns that are only partially destroyed, the distribution of the damaged buildings illustrates the same law. At Charleston in 1886, the injury to houses was greatest on low-lying "made" land; and this was also the case twenty years later at San Francisco and in 1908 in Sicily and Calabria. Even in the non-destructive shocks of this country, local variations of intensity depending on the nature of the ground are frequently observed. Shocks are much less strongly felt in houses built on hard rocky ground of Malvern and Stirling than in those situated on the plains at the hill-foot.

Important as the nature of the site undoubtedly is in an earthquake country, the magnitude of the death-rate is affected still more by the structure of the buildings. The defects which are chiefly responsible for high death-rates could hardly be illustrated more clearly than in many of the older cities of Italy. In the Basilicata, the mediæval towns and villages are almost universally perched upon the summits and steep slopes of hills and their spurs, the houses being built at the very edge of precipices. The streets are narrow, sometimes only five feet, not often more than fifteen feet, in width. The houses are generally built of limestone and brick, but the limestone is seldom well-bedded and therefore cannot be raised in long flat blocks. The mortar is poor from containing too much lime and from the lack of a proper quality of sharp sand. Thus, even the best walls, according to Mallet, consisted of "a coarse, short-bedded, ill-laid rubble masonry, with great thickness of mortar joints, very thick walls, without any attention to thorough bonding whatever." The floors are heavy and the roofs, which are hardly less massive, are covered with large tiles secured, except at the ridges, by their own weight alone.

Houses of this description were ill adapted to withstand the rough shock of the Neapolitan earthquake of 1857. At Saponara, where the death-rate amounted to 50 per cent, the buildings, when shaken down fell against and upon those beneath them and thus increased the common ruin. When Mallet, who investigated the earthquake with such skill, reached the place, "the summit and far down the slope all round presented nothing but a rounded knoll—shadowless and pale—of chalky stone and rubbish, without line or trace of street remaining; it might have seemed an abandoned stone quarry or the rubbish of a chalk pit, save that its rounded and monotonous outline was broken here and there by beams and blackened timbers that, rooted in the rubbish, stood thrown up in wild confusion against the sky-line like the gaunt arms of despair."

Though no doubt more firmly built, the houses of Messina suffered greatly from their heavy stone floors and staircases. "In some cases," writes a visitor to the city soon after the earthquake, "the whole center of the house had fallen leaving the empty case of the outer walls inclosing a heap of broken rubbish. In others and these are more numerous, the main walls fell outward, leaving the core of the house exposed like an open doll's house, with the floors intact. . . . But in most cases the house had fallen entirely, leaving a shapeless mound." Thus, almost universally, the floors and roof seem to have parted from the walls, owing to the weight of the former and the slightness of their connection with the walls. The streets were so narrow, the greatest width not exceeding twelve yards, that they were in many cases completely blocked by fallen masonry, which rose to an average height of more than five yards; so that, even if people could have escaped from their houses, it would only have been to die in the streets. In the Riviera, again, the houses in some of the coast-towns are built of rounded stones collected from the beach, bound by the poorest kind of cement; they are lofty in proportion to the foundation and thickness of the walls, and arches in the walls are common even in the upper stories and often abut against the walls without any lateral support. In the private houses injured by the earthquake of 1887, it is estimated that more than 90 per cent of the dead bodies were found crushed beneath fallen arches.

Of the six conditions which govern the high death-rate of earthquakes, we are chiefly concerned only with the last three. We cannot in any way limit the time of occurrence of a great earthquake nor can we prevent the rapid succession of strong after-shocks. Fore-shocks when they occur and the preliminary sound may provide early notice of the coming shock but, unfortunately, they are characteristic of slight as well as of disastrous earthquakes. Weak shocks may come alone and we cannot distinguish between such isolated tremors and the forerunners of a catastrophe. Moreover, when they assume the latter aspect, the interval that may elapse before the great shock comes is of uncertain duration. It may be a few minutes or hours, it may amount to days or weeks. The preliminary sound and tremor differ in this respect. Both precede the shock by a few seconds; and except in large and lofty buildings a warning of even five seconds may be sufficient. Pheasants and other birds are often terrified by the early tremors of an earthquake; but when kept by the late Prof. Sekiya for the purpose they failed to serve as satisfactory heralds. The deep earthquake-sound, again, is not equally audible to all persons. It is so low that to some, who are not in the least deaf to ordinary sounds, it is quite inaudible. There is also reason to believe that races differ in their capacity for hearing the earthquake-sound; and it is possible that a general deafness toward the earthquake-sound may result in raising the death-rate. When this defect exists, it might perhaps be remedied by the use of sensitive flames adjusted so as to respond to the deepest sounds alone.

All attempts to issue earthquake-warnings have failed and have deserved to fail, for the supposed forecasts have been based on insufficient data. Without some knowledge of the origin of earthquakes and of the movements which precede the final catastrophe, such attempts were of necessity futile. But, with the recent growth of our knowledge, it seems by no means impossible that we may in time be able to provide rough forecasts of a coming shock. To be of service, such forecasts should give the approximate time at which an earthquake may be expected and the region in which its severity will be chiefly concentrated. To furnish both elements is at present beyond our powers. But to give one only may be useful and of the two elements it is of greater value to know the area that will be mainly affected than the time when a shock will take place. The time alone would be of little service, for sixty "world-shaking" earthquakes occur on an average every year, so that as a rule few weeks will pass by without the visit of an earthquake somewhere or other upon the globe.

What is required for the solution of this problem is more definite knowledge than we at present possess of the operations which precede the occurrence of a great earthquake. On this subject, some light has been thrown by recent disasters. A displacement of the earth's crust along a fracture more than two hundred miles in length, like that which caused the Californian earthquake of 1906, cannot be the work of an instant of time. For many years, the strain must have been increasing until it reached the point when rupture and sliding could no longer be averted. By the erection of pillars along a line at right angles to such a fracture and by careful observation subsequently of their relative positions, the first deformations may be detected and measured. Or, again, before a great movement can take place, small obstacles to motion must be cleared away along the surface of the fracture and every such removal must give rise to a tremor more or less pronounced. The outlining of the course of a fault by the centers of numerous slight shocks, as happened before the Japanese earthquake of 1891, should reveal the preparation that is being made for a great movement—a movement which may, as in that case, take place within the next two years.

For the present, it would seem advisable to direct attention to those conditions which are partially within our control, so as to lessen, if we cannot avert, the destructiveness of an earthquake shock. In a few cases, there can be little doubt that the Government should interfere and prohibit the rebuilding of a town that has been frequently ruined. In permitting the re-erection of Casamicciola after the Ischian earthquake of 1883, the

Italian Government incurred a grave responsibility, notwithstanding all the precautions taken. Here, there is no reason to suspect any migration of the seismic focus. Time after time, the same small district has been the seat of renewed shocks of increasing violence. The central volcano of Epomeo may have been extinct during the historical period but outbursts have occurred along radical fissures. The violent shocks which preceded the last eruption in 1302 were similar to those which have occurred recently in the island and there is reason to fear that the Ischian earthquakes of 1796, 1828, 1881 and 1883 are merely symptoms of underground activity which sooner or later may result in forming a new lateral cone on the present site of Casamicciola.

Of most towns, especially of those which lie along the coast, the partial removal is all that can be considered. A harbor like that of San Francisco, which has no rival for hundreds of miles and which lies close to the shortest route from Panama to Yokohama and Shanghai, cannot be transferred. Nor can those along the western coast of South America, subject though they be to the inrush of seismic sea-waves. The utmost that can be attempted in such cases is to shift the residential quarters farther inland, just as, after the earthquake of 1692, Port Royal was maintained as a naval station while the town of Kingston arose in place of that which sank beneath the sea. The removal of a town, however, is a remedy so desperate that it will seldom be entertained; and as the recent experience of Kingston has shown it may not be altogether effectual. We must, therefore, as a rule, avail ourselves of the alternatives at our disposal and endeavor to mitigate the effects of earthquakes by the choice of suitable sites and modes of building.

As regards situation, it is clear that, in the absence of a protecting sea-wall, low-lying land along shores that are liable to be swept by seismic sea-waves should be avoided. All buildings, especially lofty ones, should be erected on a rocky foundation, never if otherwise possible on sand or gravel. Soft friable beds resting on a slope of rock or forming the edge of a cliff or steep river-bank are perhaps the worst of all foundations. Not only is the shock more strongly felt on them than on the adjoining rock, but the beds as a whole may slide downwards or forwards and be extensively fissured by the action of the shock.

In all cases, however, even in those in which an inferior site can be avoided, the loss of life may be diminished by erecting only houses that are adapted to withstand the strain of an earthquake shock. To erect a building that is comparatively earthquake-proof and at the same time fire-proof is merely a question of expense. The walls must be very strong at the base and as light toward the top as may be consistent with strength; they must be firmly braced together by iron rods from front to back, from end to end and from foundation to roof, so that the whole may vibrate practically as one mass. Public buildings should be of this type; but in the case of ordinary dwelling-houses the expense of such methods would be prohibitive. Fortunately, approximate safety in such cases may be secured by other and less costly means. During his long and fruitful residence in Japan, Prof. Milne determined the principal conditions which should govern construction and the following description of an ideal house is founded on the conclusions at which he then arrived.

The houses are built in wide streets, with deep foundations and are not as a rule more than two stories high. The walls are at once light and strong. They consist of a framework of wooden beams, firmly braced together, the intervening spaces being filled with light stone or hollow bricks. There are no gable-ends and the corners of the houses are specially strengthened. Nor are there any arches, except perhaps in the cellars and then they are high, curve into the abutments and are protected above by a lintel of wood or iron. The openings for doors and windows in successive stories are not placed in a vertical line and are at some distance from the corners of the house. The roofs are light and low-pitched and all tiles, if used, are fixed by nails. The floor-beams in alternate stories are at right angles and penetrate nearly the whole thickness of the walls. Chimneys, if forming part of the house, are short and thick and without heavy ornamental copings; if in the center, they penetrate the roof without touching it. Balconies are altogether absent and the staircases, if connected with the main walls, are light. No portions of the house are allowed to vibrate separately from the rest and with different periods. The one object throughout is to produce a light, strong and fairly elastic house, which, in the day of trial, shall vibrate as a whole and, while bending before the shock, shall yet endure.

How greatly such methods may contribute to the saving of life has been admirably illustrated by Prof. Omori in his recent report on the Messina earthquake. On October 28th, 1891, a violent earthquake devastated the provinces of Mino and Owari in Japan. The shock was more than four times as strong as the Messina earthquake and was felt over an area ten times as great but the total number of victims was only 7,273. Not far from the origin of the earthquake lies the city of Nagoya with a population in 1891 of 165,000. Here, though the intensity of the shock was slightly greater than at Messina, only 190 persons lost their lives instead of about 75,000 at the latter city. Thus, taking the difference of population into account, the number of persons killed in Messina was about 430 times as great as in Nagoya; or as Prof. Omori forcibly remarks, about 998 out of every thousand persons killed in Messina fell victims to the faulty construction of their houses.

Recent Experimental Study of Reflex Action

THE brilliant Russian physiologist, Pawlow, has for some years been conducting an exhaustive investigation by scientific laboratory methods of the reflex action of animals. Certain results of his latest studies are interestingly *résuméd* by Prof. Lüthje in the *Deutsche Revue*, from which we quote:

"Pawlow now no longer speaks of psycho-reflexes, but of conditioned and unconditioned reflexes. The latter are those which invariably occur when the appropriate stimulus finds a sensory path, as when food is put in the mouth, and a flow of saliva follows. A conditioned reflex, on the other hand, is one which occurs only under certain given circumstances: if food is frequently shown to a dog, and afterward given him to eat, after a certain number of experiments a flow of saliva will occur at the mere sight of the article (a 'natural conditioned stimulus').

"'Artificial conditioned stimuli' have the same effect. If a given musical note be repeatedly sounded at the same time that a given article of food is offered to a dog, after a certain lapse of time the mere sounding of the note will produce a corresponding flow of saliva. But the saliva will fail to flow if there be even a minimal variation in the tone. Similarly other external conditioned stimuli (optical, thermal, etc.) can be formed, if the same stimulus is repeated a number of times synchronously with an unconditioned stimulus, such as the taking of food.

"Hence, this so-called psychical process is resolved into a comprehensible, scientifically definable reflex process. 'Everything in the external world; all sounds, sights, odors, etc., can be brought into temporary combination with the salivary gland, and become a stimulus of that gland, when made to coincide for a time with the unconditioned reflex stimulating the same gland. In short, we can create as many conditioned reflexes for the salivary gland as we please, and turn what we please into a conditioned reflex.'

"He says further: 'When a new, previously indifferent stimulus arrives in the cerebral hemisphere at the same moment that some strong nervous excitement affects the same locality in the nervous system (stimulated by some synchronous unconditioned reflex), then this new stimulus begins to concentrate itself, and in a certain degree to make for itself a path to the excited locality and back again to the corresponding organ, and in this manner becomes a stimulus of this organ. In the opposite case, when no such excited locality is present, the stimulus is dissipated, without perceptible effect in the mass of the cerebrum. *This formulates the fundamental principle of the highest division of the nervous system.*'

"Together with this reflex mechanism are manifold inhibition devices, checked in their turn by inhibition controls; phenomena now subject to exact analysis by the methods of Pawlow. 'The highest nervous activity' is now regarded as a balancing of the three fundamental processes: the stimulation, inhibition, and inhibition control of conditioned reflexes. . . . 'As a part of nature, each animal organism represents a complicated separate system, whose inner forces, so long as the system exists as such, maintain an equilibrium with the external forces of its environment. *The more complicated the organism the more numerous, manifold, and delicate the elements of this equilibrium.* In this are involved both the "receptors" (i. e., the organs of sense and the mechanism of both conditioned and unconditioned reflexes, which create the most precise relations between the smallest elements of the external world and the most delicate reactions of the animal organism. In this wise all life, from the simplest to the most complicated organisms, including man, may be regarded as a long series of increasingly complicated cases of the establishment of equilibrium with the external world. The time will come—distant though it may be—when mathematical analysis, resting upon scientific analysis will comprehend that relations of equilibrium in majestic formulæ, including finally, itself.'"

Long Lived Locomotive Engineers

IN addressing the Conference Committee of Managers who were investigating the question of increased pay for engineers Mr. W. W. Atterbury, vice-president of the Pennsylvania, submitted an array of interesting statistics, among them figures which showed that engineers on the Pennsylvania Railroad live longer than any other class of employees. "As an actual fact," he said, "we have 202 engineers on the pension roll—7.6 per cent of the pensioned employees are engineers and they are drawing 12 per cent of the pensions. The average amount paid to all pensioned employees per month is \$23.95; the engineers' average is \$41.35.

"The average length of service of engineers, of those men who died from natural causes, was 21 years, and the average length of service as engineer of those who died as a result of accident was 13 years, and the average length of service of the enginemen of all men who died was 18.

"It is rather curious and it is exceedingly interesting," said Mr. Atterbury, "to note that the average age at death of all classes of our employees, officers and everyone else was 49 as against 51 for engineers and for those the average age at death, as the result of accident, was 33, for all, as against 42 for engineers."

In other words, apparently the engineer's length of life is longer than that of any other of the railway employees of which any record is kept.

This is entirely different from the popular belief respecting mortality among locomotive engineers, who are considered a short-lived class, an impression that no doubt comes from want of accurate information.—*Railway and Locomotive Engineering.*

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